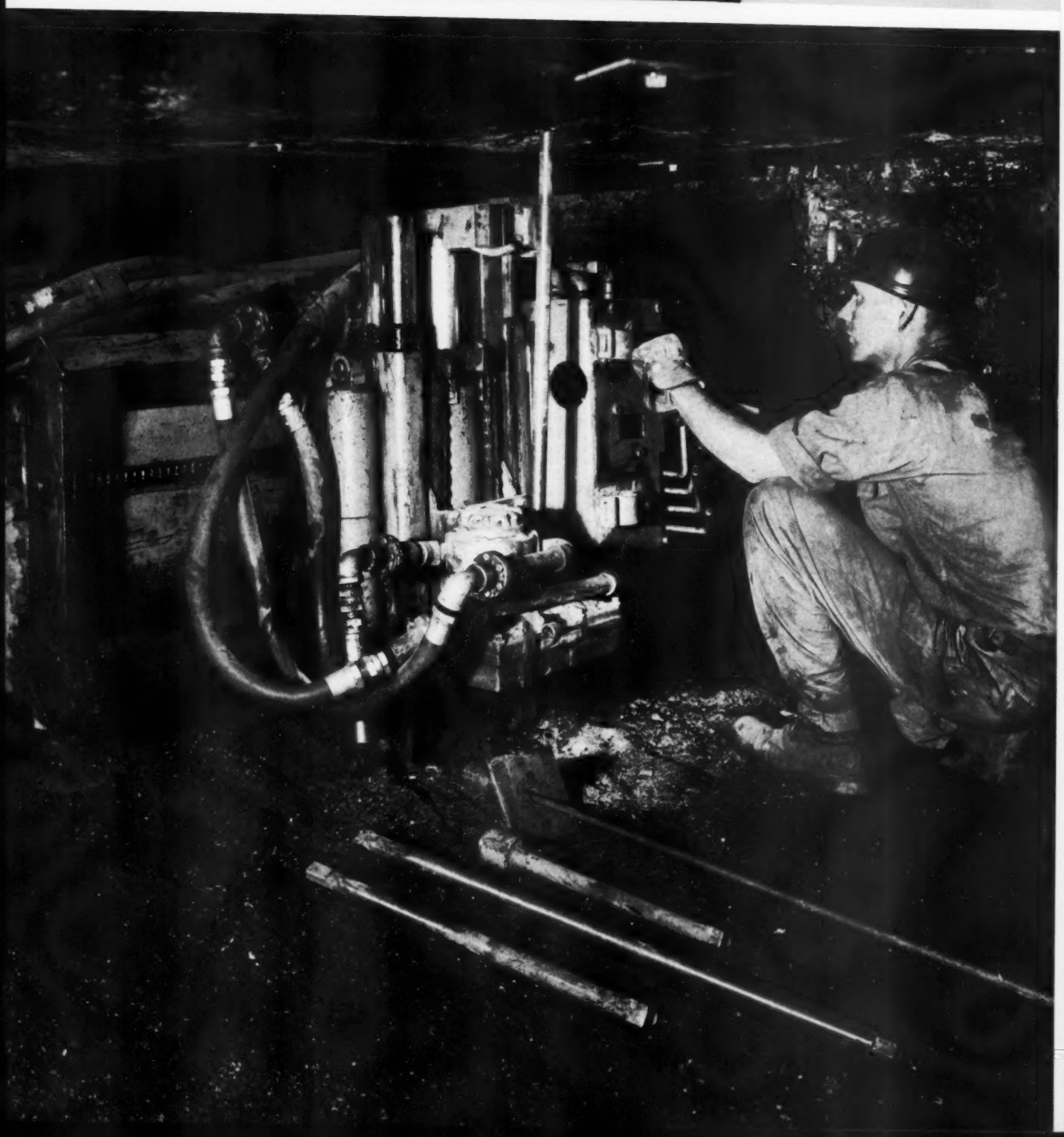
MINING CONGRESS JOURNAL

OCTOBER 1960



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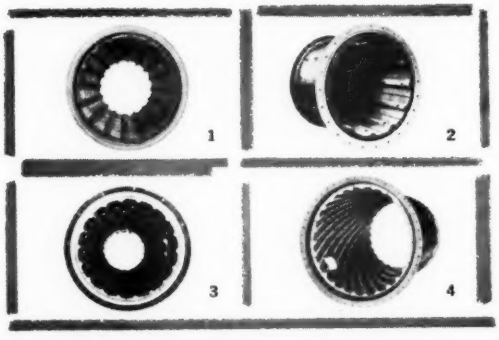
The right liner lasts longer — and often increases the capacity of your mill. *Ask your A-C representative to look into your shell liner problems, or write* **Allis-Chalmers,** *Industrial Equipment Division, Milwaukee 1, Wisconsin.* A-1366



These four types of liners demonstrate how liners can vary over a wide range of design characteristics to meet the specific requirements of a job. Pictured: **(1)** Lorain liner, **(2)** wave type, **(3)** wedge type and **(4)** spiral liner.

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Opinions expressed by the authors within these pages are their own and do not necessarily represent those of the American Mining Congress.

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ON OUR COVER

Installing roof bolts at a South-East Coal Co. mine in eastern Kentucky.

Published Monthly. Yearly subscriptions, United States, Canada, Central and South America, $3.00. Foreign, $10.00. Single copies, $0.75. February Annual Review Issue, $1.25. Second class postage paid at Washington, D. C., and at additional Post Office, Lancaster, Pennsylvania.

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featured IN THIS ISSUE—and the AUTHORS—

SLUSHER OPERATION ON NARROW VEINS SOLVES STOPING PROBLEM

At the Fairview mine of Aluminum Company of America, characteristics of the vein material and the narrow vein widths caused the broken ore to arch and bridge when the stope was drawn. When the conventional shrinkage stoping method was modified to the use of slushers, a dangerous and difficult operation became safer and more flexible.

SONAR EXPLORATION OF COAL MINE ROOF STRATA

More than 50 percent of all coal mine fatalities and 25 percent of the non-fatal serious injuries are the results of falls of roof, face or rib — indicating the importance of the problem of roof control. In June 1950 the U. S. Bureau of Mines instituted an investigation to determine whether sonic techniques could be applied successfully to determine mine roof conditions not readily discernible by visual inspection. Here is a full report on the Bureau's approach and experimental work — together with an evaluation of the status of the project.

INNOVATIONS IN AMMONIUM NITRATE BLASTING MIXTURES

Field-mixed ammonium nitrate-fuel oil mixtures, along with the innovations that have been developed in the use and handling of them, have enabled many mines to greatly reduce operating costs without relaxing prudent safety measures in any way. The author gives a definition of a blasting agent and describes recent developments in ammonium nitrate bulk handling, mechanical hole loading, and slurry explosives.

FINE COAL CLEANING WITH TABLES

More than 55 percent of all slack in the Pocahontas field will probably be cleaned on tables in 1960. In covering the experience of this area with tables, the authors tell how table capacity depends on washability of the raw coal, ash requirements in the clean product, amount of refuse in the raw feed, and size and ash consist of the raw feed. The report also considers the efficiency of tables — how it varies with the different sizes of coal — single-deck versus double-deck performances, and required auxiliary equipment.

(CONTINUED ON PAGE 5)

William H. Harrison, Jr., is general mine superintendent at the Fairview mine of Aluminum Co. of America. A registered professional engineer, his experience includes metallic and nonmetallic mining, both surface and underground, in the United States and South America. He has been in supervisory positions with Alcoa for eighteen years.

Thomas C. Miller and Charles E. Mongan, Jr., coauthored the report on sonic techniques. Prior to his present position as Mining Health & Safety Engineer, Roof Control Research Group, U. S. Bureau of Mines, Miller

T. C. Miller

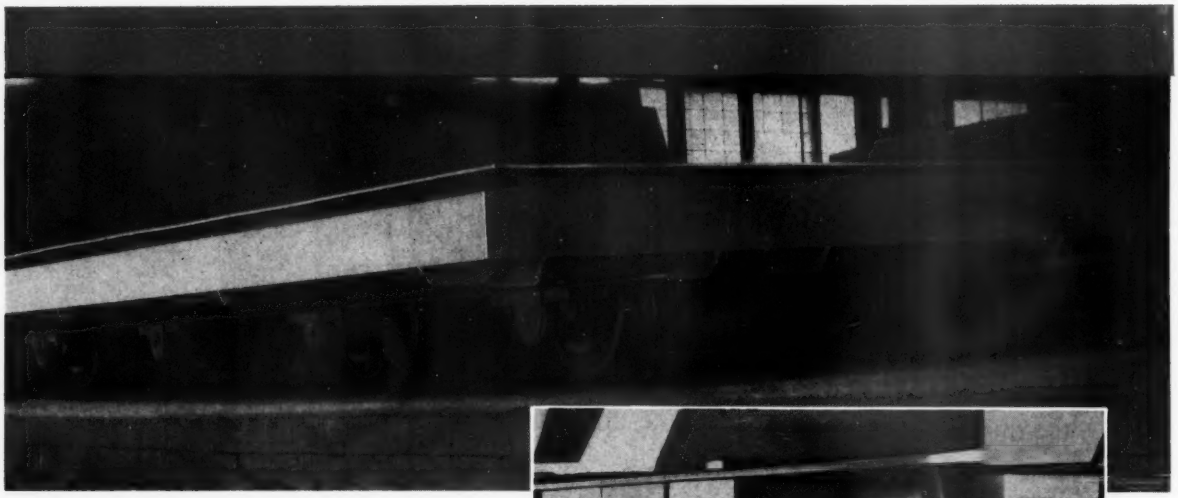
C. E. Mongan

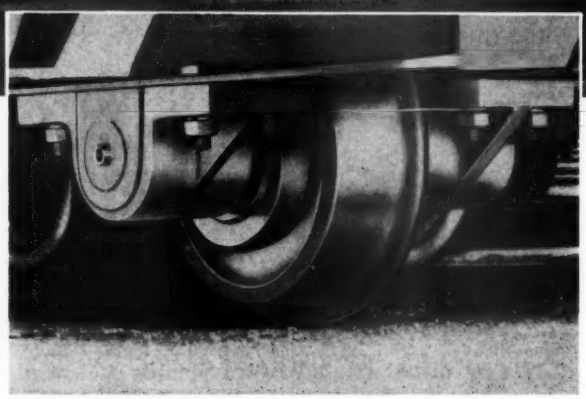
had served in various positions for Semet-Solvay Co. and Eastern Gas & Fuel Associates in engineering, purchasing, safety inspection and operating departments. Mongan, a consultant-physicist for the Bureau's Roof Control Research Group, has served in various positions for Hartford-Empire Co., Pacific Division of Bendix Aviation, E.D.O. Corp., and Scully Signal Co.

Donald M. Stromquist is a graduate chemical engineer and a registered professional engineer. He is a technical representative in the Coal Chemical Sales Division of U. S. Steel Corp., which he joined four years ago. Prior to coming to U. S. Steel, he was associated with Illinois Water Treatment Co. for ten years.

Charles William Porterfield joined Pocahontas Fuel Co., Division of Consolidation Coal Co., in 1950 as test engineer. He was made assistant mechanical engineer in 1952 and in 1959, director of Research-Testing and Sales Liaison. He was assisted in the preparation of the article on fine coal cleaning by two well qualified men from his company—Messrs. A. E. Copeland, assistant chief engineer, and Guy N. Haynes, superintendent of preparation plants.

C. W. Porterfield





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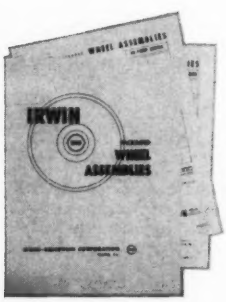

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(CONTINUED FROM PAGE 3) **IN THIS ISSUE—and the AUTHORS—**

MINERAL RESOURCES ON THE OCEAN FLOOR

Ocean floors contain materials which could well be profitable ores—available for mining today. Why haven't they been exploited before? Probably because few people know about them, but also because of the formidable technical problems in mining them efficiently. Although there are many facets of the ocean to be explored in regard to minerals recovery, this discussion is confined to pelagic sediments

Dr. John L. Mero has been employed by the University of California, Department of Mineral Technology, since 1957 in research on recovering minerals from the ocean. He was awarded the D. C. Jackling Fellowship in 1960 to continue this research.

BELT MAINTENANCE AT WEST KENTUCKY COAL CO.

Up to $3900 per hour—that's how much it can cost West Kentucky Coal Co. if its haulage system ceases to function. Here is the full story on a maintenance program that has limited belt delay time to an average of ten minutes per operating day and raised belt life to 19 years in some applications.

After receiving a B.S. degree in Mining Engineering with a coal option from the Missouri School of Mines in 1954, Buddie Ray Morris went to work for Union Electric Co. as a mining engineer. Since 1956 he has been with West Kentucky Coal Co., Inc., as an industrial engineer.

IRON MAKING BY THE DWIGHT-LLOYD MCWANE PROCESS

This informative article describes, for the first time, a new method of making iron that incorporates a Dwight-Lloyd process within a multi-stage system of smelting. Interesting features of the process are that it uses proven metallurgical apparatus and inexpensive raw materials.

Robert C. McDowell has had 25 years of experience in various phases of structural fabrication, design and construction. He was general manager of Cleveland Steel Erection Co. before organizing McDowell Co., Inc., an engineering and contracting company, in 1944. He has been president of Wellman Engineering Co. since 1955 and is also president of McDowell Co.

AUTOMATION OF THE MOUAT MINE AERIAL TRAMWAY

Installation of a closed circuit television system and automatic equipment have greatly improved the efficiency and safety of the aerial tramway — a vital link between the mine and the mill. Constant observation of each phase of the operations is essential as American Chrome strives to achieve the most efficient and safest operation possible — both important factors if a reliable source of ferrochrome produced from domestic chromite ores is to be available to the steel industry.

Guy P. Morris is mechanical and electrical superintendent for American Chrome Co. at Nye, Mont., where he has been employed since 1953, following six years of tunneling construction work for various contractors in Colorado. Before entering the construction field in 1947, he had been a sales engineer for Ingersoll-Rand Co. for about ten years.

Watch for the November issue which will carry a full report on the 1960 AMC Mining Show

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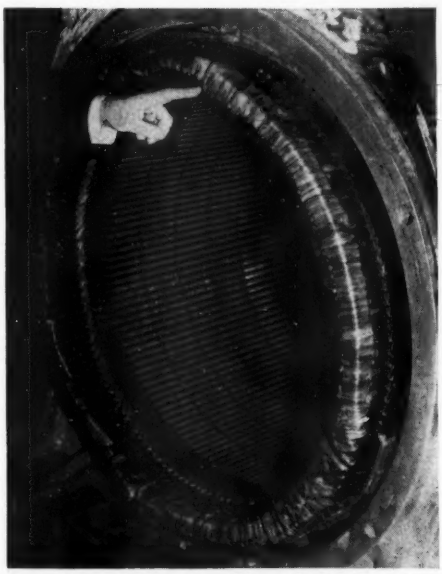

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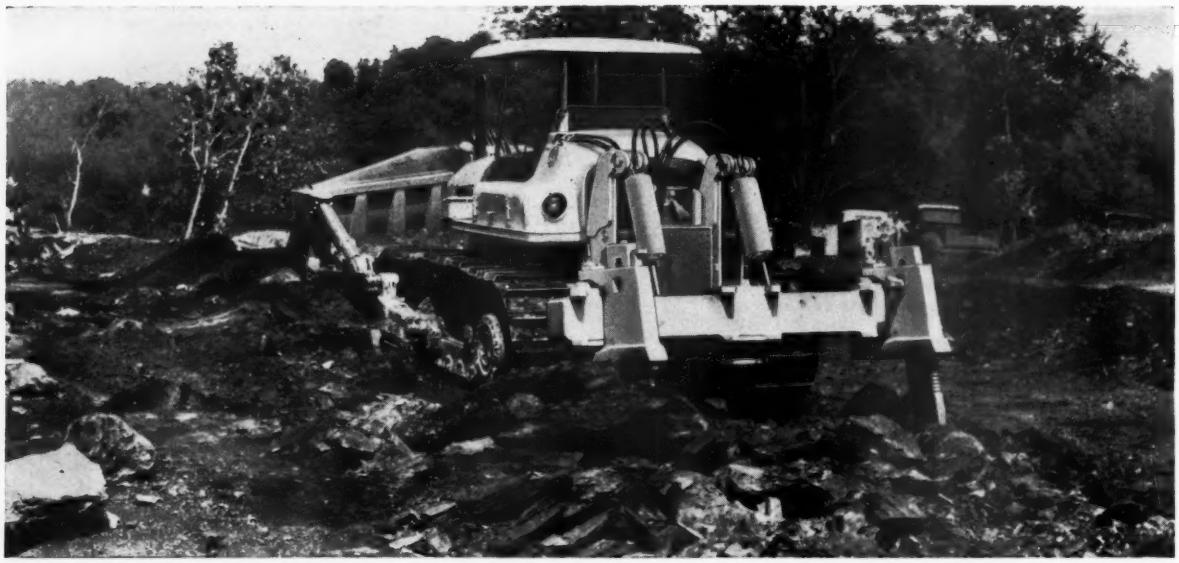

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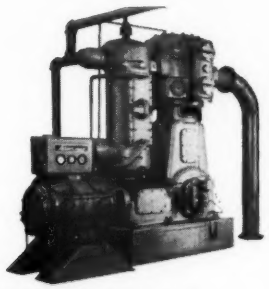

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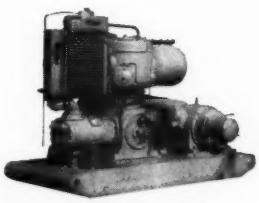

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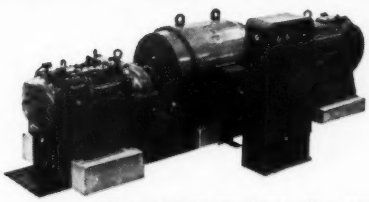

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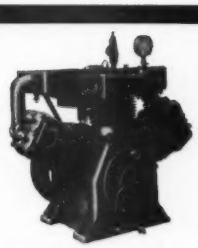

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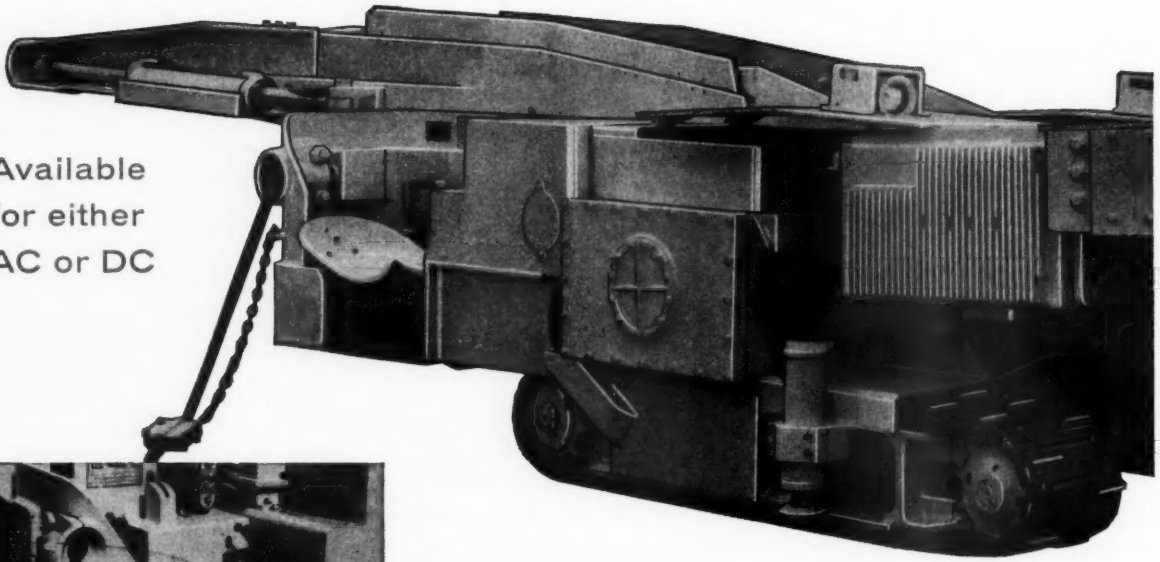

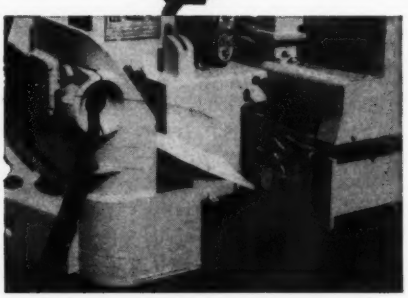

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Compact and convenient hydraulic and electrical controls are within easy reach of the operator. Throttle valve precisely controls the speed of all hydraulic operations as well as providing "deadman" control.

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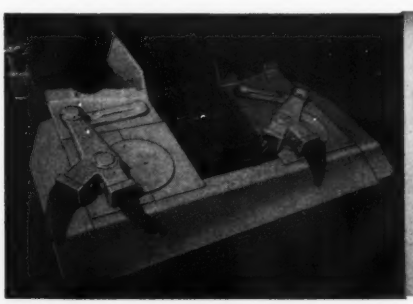
The new crawler with heavy-duty gearing can operate the miner on steep grades and also float on soft bottom.

Less than 25 P.S.I. ground pressure.



GATHERING HEAD

The exclusive "dual gathering arms" provide maximum reach and much better flow to the conveyor.

PERFORMANCE PUNCH

Lee-Norse CM38 and CM48 MINERS

29 TONS with power-smooth cutter-action that cuts 42" to 120" seams and gathers loads as fast as they are cut

CUTTING HEADS

New "Rap-Lok*" Cutter Bits, spaced evenly around cutter rim, provides smooth, vibrationless performance. Extremely quick "bit change"—no set screws—long bit life.

*Trade Mark of The Cincinnati Mine Machinery Co.

Lee-Norse Company

CHARLEROI, PENNA.

Specialists in Coal Mining Equipment

Coal high or low?... Lee-Norse MINERS keep production on the go!

US RUBBER CONVEYOR BELT

OFF WITH THE OLD, ON WITH THE NEW

20-year "U.S." veteran makes way for new "U.S." Belt

Here's why: This was a "Haul of Fame" slope belt in performance—every foot of the way. Installed in Sahara Coal Company's Mine No. 5 (Harrisburg, Ill.) over 20 years ago, this U. S. Matchless® 54" slope belt was replaced by a new U. S. Matchless.

In the 20 years, the old belt carried over 13 million tons of raw coal, plus well over a million tons of rock.

This enviable record is typical of the kind of service obtained with U. S. Conveyor Belts. The Sahara Coal Company pioneered with U. S. Rubber in the design and installation of both slope and underground belts to deliver lowest ton-per-dollar and not a belt at-a-price.

• • •

When you think of rubber, think of your "U. S." Distributor. He's your best on-the-spot source of technical aid, quick delivery and quality industrial rubber products.

US RUBBER Mechanical Goods Division

United States Rubber

WORLD'S LARGEST MANUFACTURER OF INDUSTRIAL RUBBER PRODUCTS

Rockefeller Center, New York 20, N.Y. In Canada: Dominion Rubber Company, Ltd.

Thor

Announces TWO great new Push Feed Drills···

and more!

MODEL 330, with new larger bore, out-performs anything in its class.

MODEL 440, with 50% longer stroke, shatters all records for fast penetration in hardest rock!

And there's more · · ·

New Power-Retracted Legs for either the Model 330 or Model 440 up to 51-inch feed!

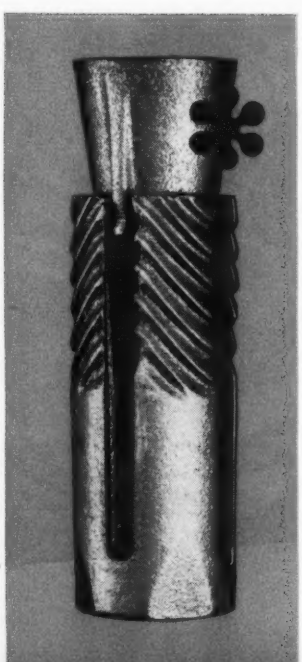
New Telescopic Legs for either the Model 330 or Model 440—up to 72-inch feed!

The all-new Thor Push Feed equipment has dazzled mining people everywhere it has been demonstrated—with tremendous penetration, plus new simplified controls that make it the easiest to use equipment on the market today.

Don't get caught napping! Write now for a demonstration on your property. Thor Power Tool Company, Aurora, Illinois. Branches in principal cities.

Thor POWER TOOLS

A 4-way expansion unit that holds in soft shale or hard rock



4-WAY EXPANSION UNIT BUILDS HOLDING POWER FAST . . . because the flexible fingers of the shell are slightly pre-expanded to grip the wall even before wrenching begins.

GOES UP FAST AND STAYS PUT. When the bolt is shoved up the hole, the expansion unit holds the bolt in place until it's tightened . . . no need to have hands exposed to injury during wrenching.

GREATER STRENGTH IN HARD TOP . . . BETTER "PURCHASE" IN YIELDING TOP . . . because the expansion pressures are spread evenly over the four shell fingers to make the best use of the entire unit's strength. These are the reasons for the O-B Expansion Unit's popularity with mining men. It is easy to understand why more mine roof is supported with O-B Shells and Plugs than with any other kind.

For further information and prices, see your local O-B sales-engineer or write us now. OHIO BRASS COMPANY, MANSFIELD, OHIO. Canadian Ohio Brass Company, Ltd., Niagara Falls, Ontario.

Ohio Brass B HOLAN

EXPANSION SHELLS AND PLUGS • LINE MATERIALS • SAFETY AND CONTROL EQUIPMENT • ELECTRIC HAULAGE MATERIALS

10048-M

HOW TO MAINTAIN GAGE AND SPREAD AT THE HEEL ENDS OF SWITCHES

There's really no trick to it, if you equip your turnouts with Bethlehem's Design 992 Switch Heel Block.

Fitting snugly between the stock rail and the closure rail and switch point, this sturdy device was designed especially to maintain track gage and heel spread at the heel end of a mine-track switch. Bushings welded to one side of the block permit you to draw bolts up tightly without in any way limiting normal movement of the point. At the same time, the Design 992 keeps closure rail and switch point in correct alignment, both vertically and horizontally.

You can get the Design 992 Switch Heel Block to fit any length of switch or weight of rail, from 40 lb per yd on up. Your own men can install this efficient device quickly, and the operating results will be gratifying. Let one of our engineers demonstrate the value of Bethlehem Switch Heel Blocks for your haulage system.

BETHLEHEM STEEL

BETHLEHEM STEEL COMPANY, Bethlehem, Pa. EXPORT DISTRIBUTOR: Bethlehem Steel Export Corporation

Repower with A-C 21000 diesel

Repowered with an Allis-Chalmers 21000 diesel, this truck now hauls more than 2,000 extra tons per week for L. J. Botcheller, Inc., Scranton, Pennsylvania.

...boost truck output 25%

L. J. Botcheller, Inc. put an Allis-Chalmers 21000 diesel into a truck used on coal silt mining at Carbondale, Pennsylvania, and boosted truck output 25 percent.

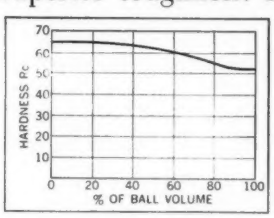
The truck body had been modified to carry a payload of 72,000 lb. Gross vehicle weight is 121,000 lb. Previously, five to seven 2-mile round trips were made per hour, with first gear used on grades. Now, with the new Allis-Chalmers 21000 diesel, the truck makes seven or eight round trips per hour and takes grades in second gear.

The 21000 diesel provides enough power and speed to haul an extra 50 tons an hour *—and requires no additional fuel to do it!* This is further proof that the 21000 has the power for tough jobs, as well as the best fuel economy in the business. See your Allis-Chalmers dealer about putting this modern diesel to work in *your* equipment. Allis-Chalmers, Milwaukee 1, Wisconsin.

ALLIS-CHALMERS
***POWER* FOR A GROWING WORLD**

BC-33

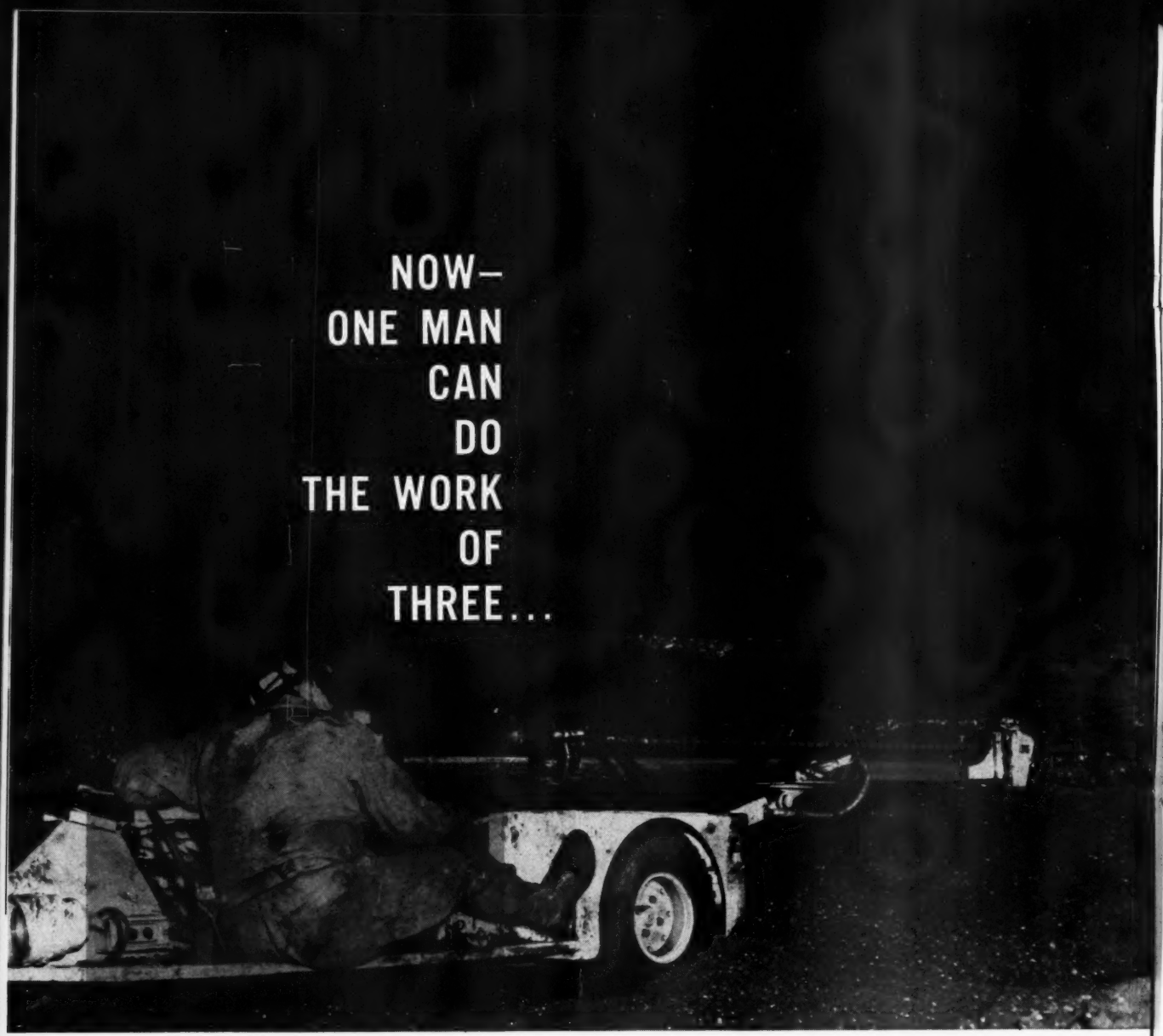
Immediate delivery on USS Grinding Balls We swing into action immediately when you order USS Grinding Balls. Thus, they are delivered to you when you need them. We can ship promptly from stock that includes a complete range of sizes from ¾″ to 4″ in USS Carbon-Manganese Steel and USS Alloy Steel. Here are three reasons why USS Grinding Balls are your best buy: **Maximum hardness** combined with superior toughness. **Deeper hardness penetration** achieved by careful combination of heat treatment and composition. **Uniform roundness** from ball to ball, load to load, for less wear and superior performance. If you have a delivery, performance, or selection problem, call our nearest Sales Office or United States Steel, 525 William Penn Place, Pittsburgh 30, Pennsylvania.



USS is a registered trademark

This mark tells you a product is made of modern, dependable Steel

United States Steel Corporation—Pittsburgh
Columbia-Geneva Steel—San Francisco
Tennessee Coal & Iron—Fairfield, Alabama
United States Steel Export Company
United States Steel



LONG TDF-10 Mobile Coal Drilling Machine shown drilling over dust after cutting. Unit is equipped with racks for AIRDOX tubes.

By utilizing a LONG Mobile Coal Drilling Machine and the new AIRDOX System of Mobile Multiple Shooting, one man can quickly handle drilling and shooting in all seam heights, even as low as 28″. Result: you can realize substantial savings in face preparation costs.

Here's but one example of how this system works. The operator drills four holes, inserts AIRDOX tubes, and then shoots them in proper sequence *and in a single operation.* The new AIRDOX automatic discharge heads enable tubes to be reused any number of times without removing or replacing shear strips. And AIRDOX non-explosive shooting produces a better product that's easier, more economical to load and clean.

The LONG TDF-10 Mobile Coal Drilling Machine offers features that will enable more mines to take advantage of these benefits of AIRDOX Multiple Shooting. This self-tramming, highly maneuverable machine has a "rotary thrust" drill head, with auger guides positioned only 10″ from the face. It provides faster, surer drilling . . . will drill a 9′ hole in only 12 seconds.

For complete details on this cost-cutting system for one-man drilling and shooting, ask your Long-Airdox representative; or write Long-Airdox Company, Division of Marmon-Herrington Company, Inc., Oak Hill, West Virginia.

LONG-AIRDOX

Conveyors at their Best!

IDLERS

SPEED REDUCERS

CONVEYOR BELTING

VIBRATING EQUIPMENT

Carrying hot calcined gypsum is the tough job of special Hewitt-Robins belts at the Shoals, Indiana, plant of U.S. Gypsum. In service since 1955, these 24" Maltese Cross butyl hot materials handling belts twist at the end pulleys, allowing the bottom cover to become the top cover, and vice versa, every other trip. This adds years to belt life.

H-R belting also:

- Provides exceptional longitudinal strength and cross-wise flexibility.
- Starts smoothly, even on "across-the-line", fully loaded belt start-ups, due to controlled, low belt elongation.

The engineering and top quality you'll find in Hewitt-Robins conveyor systems and belts are built into all H-R equipment. For full details consult your H-R representative, or write Hewitt-Robins, Stamford, Connecticut. Ask for Bulletin 10-15.

HR HEWITT-ROBINS

THE NAME THAT MEANS EVERYTHING IN BULK MATERIALS HANDLING SYSTEMS . . .

CONVEYOR BELTING AND IDLERS • INDUSTRIAL HOSE • VIBRATING FEEDERS, SCREENS & SHAKEOUTS • POWER TRANSMISSION EQUIPMENT

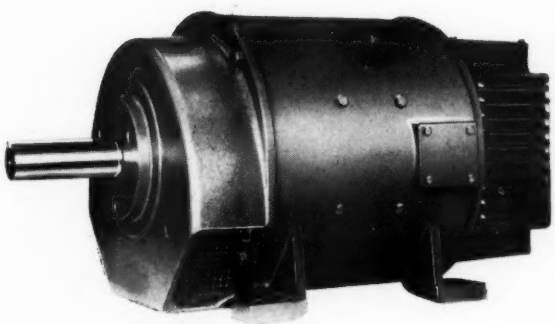
THIS IS MARION QUALITY

Excavator manufacturers don't *have* to use herringbone gears. Some do. One of them is Marion. It boils down to just how literal a manufacturer is trying to be when he says "our machines have longer life." Marion knows, and so do discerning big-machine owners, that the unique design of herringbone gears does mean longer life in the truest sense. Smoother power flow too, with less vibration. More metal is in constant shear which means the unit is delivering total power at all times. Yes, it takes more machining operations to produce them. Yes, they're more expensive. But dollar for dollar, over the life of a Marion, such significant improvements as herringbone gears give you value received "plus." Just one more example of Marion quality in action for the big mining and quarrying jobs of the Sixties. Marion Power Shovel Company, Marion, Ohio, a Division of Universal Marion Corporation.

MARION

Tough Reliance D-c. Motors power this mechanical mule

Powerful new Reliance Super 'T' D-c. Traction Motors put muscle in this low-slung mine tractor. Two low-voltage, battery-operated 5 hp. motors pull a 20-ton pay load at speeds up to 6 mph. Operation is smooth and equally responsive in forward or reverse.



These Reliance Traction Motors, used by a wide variety of manufacturers, withstand punishing overloads in starting loaded trains. Operating conditions are damp and gritty. In spite of this damaging environment, Reliance D-c. Motors have given years of reliable mining service.

This is typical of the performance you get from all Reliance products. Your nearest Reliance Sales Engineer will give you all the pertinent facts. Call him, or write for bulletin C-2501. C-1804-A

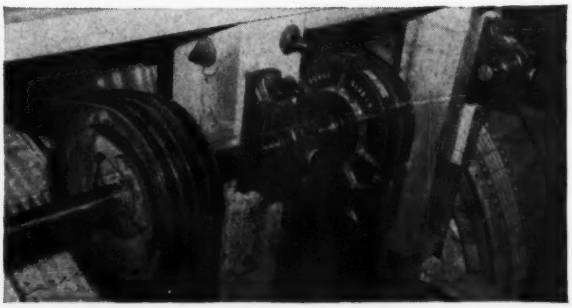
Product of the combined resources of Reliance Electric and Engineering Company and its Master and Reeves Divisions

RELIANCE ELECTRIC AND ENGINEERING CO.

DEPT. 910A, CLEVELAND 17, OHIO
Canadian Division: Toronto, Ontario
Sales Offices and Distributors in Principal Cities

Duty Master A-c. Motors, Master Gearmotors, Reeves Drives, V★S Drives, Super 'T' D-c. Motors, Generators, Controls and Engineered Drive Systems.

How Dodge pillow blocks with Timken® bearings give longer life with less maintenance



1. Two 2⅞" Dodge Special Duty pillow blocks equipped with Timken® tapered roller bearings, support the line shaft driving six by eight foot tanning drums. The tapered design of Timken bearings enables them to take both radial and thrust loads in any combination.

2. The crusher at a trap rock and asphalt plant runs faster, gives more production now that Dodge Double Interlock pillow blocks on Timken bearings are installed. The Timken bearings in these blocks give full-line contact between rollers and races for greater load carrying capacity.

3. The Timken bearings in All-Steel Dodge pillow blocks must stand up under adverse operating conditions found when sintering metals. One major advantage of Timken tapered roller bearings is their ability to hold housings and shafts concentric, thus keeping lubricant in, dirt and dust out.

The photo at right shows the Dodge All-Steel pillow block Timken bearing equipped. The specially designed bearing has a tapered bore with self-aligning spherical outer surface—never needs adjustment.

There's a Dodge pillow block equipped with Timken bearings to fill every engineering need: All-Steel, Type "E", Double-Interlock, Type "C" and Special Duty. And with Timken bearings, space consuming thrust devices are not needed. Look for Timken bearings in all the machines you buy or build. They're the symbol of quality. The Timken Roller Bearing Company, Canton 6, Ohio. Cable address: "TIMROSCO". Makers of Tapered Roller Bearings, Fine Alloy Steel and Removable Rock Bits. Canadian Division: Canadian Timken, St. Thomas, Ont.

Industry rolls on

TIMKEN®

tapered roller bearings

Have an Un-Safe haulage problem? The S-D Brakeman* could be your solution!

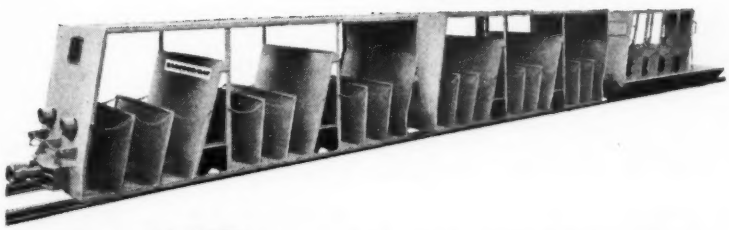
We have developed a special safety car called S-D Brakeman. It incorporates electrically operated magnetic brake shoes. Here are but a few S-D Brakeman and S-D Brakeman Personnel and Supply Trains we have engineered and built to solve particular *safety* problems. S-D Brakeman safety control cars can be designed for use with mine or railway cars to solve any number of problems at low cost — underground . . . mainline . . . tipples, etc. Write us today for BULLETIN A400. It fully illustrates in six pages many types of S-D Brakeman Cars with specifications and complete information. *Sanford-Day Iron Works, Inc., P.O. Box 1511 . . . Telephone 3-4191, Knoxville, Tenn.*

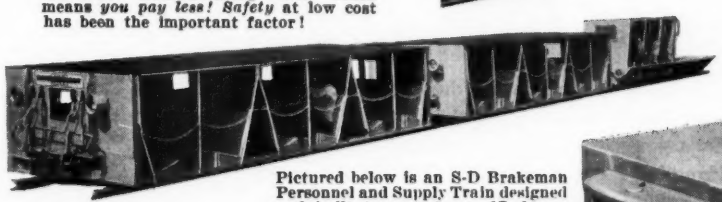
*Trademark registered

The problem this customer had was with potential break-aways when pulling upgrade on a long uphill haul. This S-D Brakeman *replaced a locomotive and operator* used to tag along behind trip as a safety measure. Controls are set on this 8-wheel S-D Brakeman for a predetermined speed, which, if exceeded, will automatically apply the brakes.

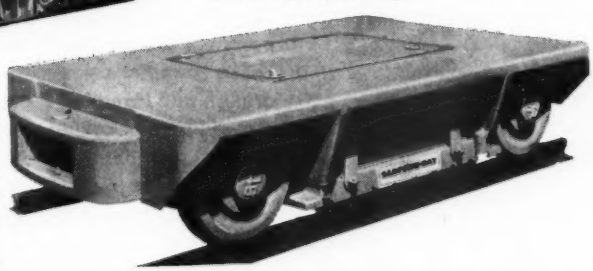
This customer needed cars to transport personnel. Train was to operate by cable on 16 degree slope. *Safe* transportation was the first and foremost consideration. Second important factor was to obtain this safety at *low cost!* An S-D Brakeman was the solution. Not only did it serve as the *safety control car* for the trip, but itself became a dual-purpose man and supply car. Therefore, it further operates independently transporting supplies and maintenance personnel.

Another customer needed an S-D Brakeman Personnel and Supply Train. In his case, however, underground haulageway required low-height train. The two S-D Man Cars are uncoupled from S-D Brakeman at bottom of slope and coupled to conventional locomotive which transports men to working areas. You will note neither design has costly streamlined construction. They are compact all-steel functional units with each steel member an integral part of the frame work. Result: Minimum manufacturing cost which means *you pay less! Safety* at low cost has been the important factor!





Below is another type S-D Brakeman frequently ordered to replace locomotive used in trips for braking.



Pictured below is an S-D Brakeman Personnel and Supply Train designed and built to operate on 17 degree slope by hoist cable. Note S-D Brakeman was built with material-handling platform to be *level* when transporting supplies on the sloping haulageway. At a pre-determined setting the *revolution of the wheel* applies the *brake shoes.*

SANFORD-DAY

KNOXVILLE, TENNESSEE

To: Sanford-Day, 612 Dale Avenue, Knoxville, Tenn.

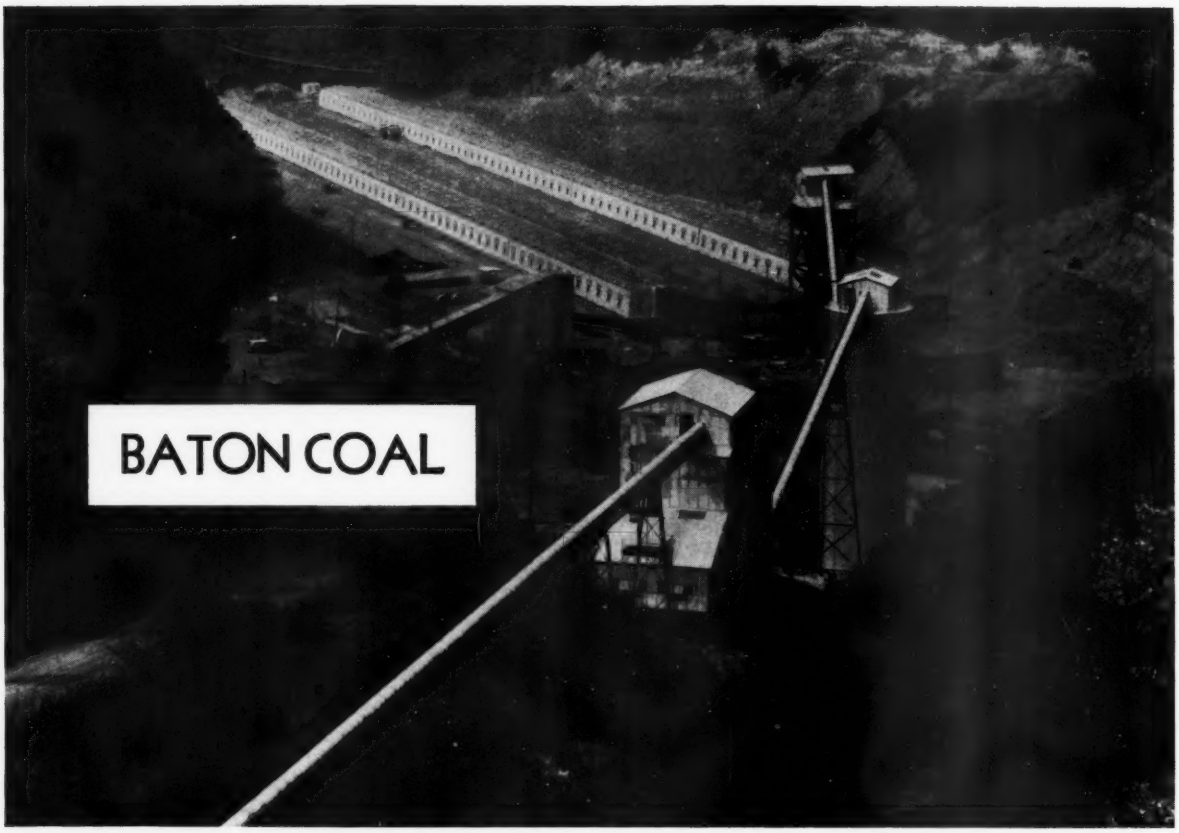
Gentlemen, please send by return mail CAR BULLETIN A400 with specifications, data and fully illustrating S-D Brakeman Cars

NAME .....

FIRM .....

ADDRESS .....

CITY ..... **STATE** .....



Carpentertown Coal & Coke Company's Mahoning Mine Preparation and Handling Plant for 180 TPH ROM Coal: H & P Heavy Media Washer, H & P Cyclones, Reineveld Coarse and Fine Coal Dryers, H & P Sieve Bends, Wet Concentrating Tables, Vacuum Filter.

From Raw Coal Hopper to Larry Bin...

it's H&P all the way!

The Baton Coal Company, operating the Carpentertown Coal & Coke Company for Sharon Steel, demands efficient operation and a quality product. These conditions governed H & P's design of the new Mahoning Coal Preparation and Handling Plant, processing 180 TPH of Upper Freeport Seam into a metallurgical coking coal which contains 80% of minus ⅛".

For coarse coal and fine coal preparation, H & P has provided only the newest proven equipment and methods, including:

For efficient coarse coal washing—the New H & P Heavy Media Washer
For economical dewatering —the H & P Sieve Bends
For troublefree thickening —the H & P Cyclones
For high-capacity drying —the Reineveld Centrifuges

The plant, from Raw Coal Hopper to Larry Bin, was designed, built and completed on time and H & P's performance has confirmed to this customer what many others already know:

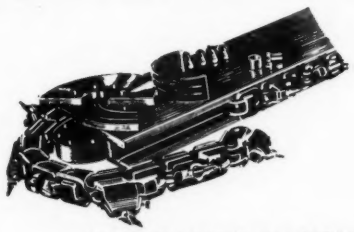
When Experience Counts—Count on Heyl & Patterson.

HEYL & PATTERSON, inc.

55 FORT PITT BLVD., PITTSBURGH 22, PA. • COurt 1-0750

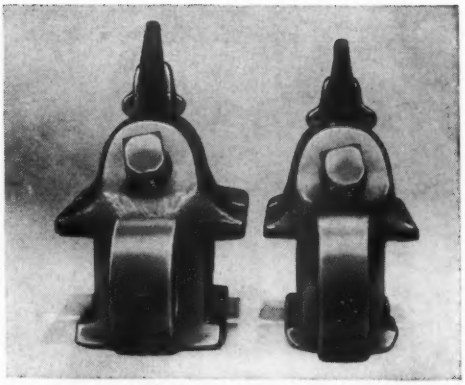
New SUPER-STRONG No. 80 CUTTERBAR

built to fit all of the newest heavy-duty machines, designed for use of the stronger new Bowdil



CHAIN #40-3

ALSO USED ON CONTINUOUS MINING MACHINES

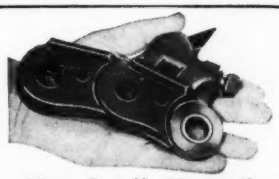


AVAILABLE WITH BIT OPENING ½" x 1" (takes all type bits)

new #40-3 **standard #40-1**

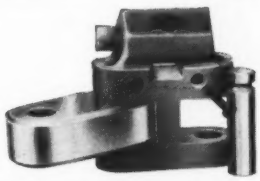
SPROCKETS FOR ALL MINING MACHINES

Bowdil Sprockets are made from special heat - treated alloy steel. Our stock of over 100 different styles includes clutch, spline and keyed types—various tooth designs of 4 to 13 teeth.



New Small, Versatile
"THIN-KERF" CHAIN and CUTTERBARS

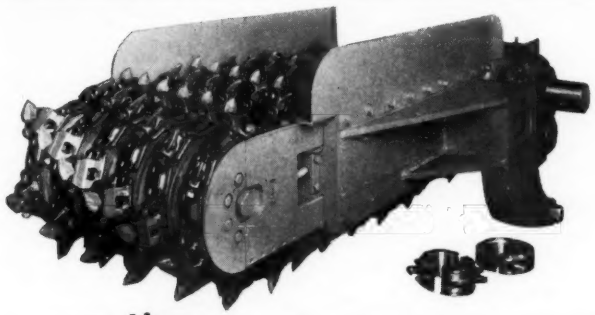
Lends itself best to use on machines delivering up to 15 h.p. and kerf of 3" to 3½". Reduces amount of cutting to the point where higher feed speeds are realized . . . and CLEANER CUTS!



Newest type TRIMMER CHAIN

for all makes of CONTINUOUS BORING MACHINES

Great strength and flexibility. Uses Bowdil Throwaway or ½" x 1" Shank Bits. Chain pitch may be varied by changing couplers only. NOTE COUPLING PIN DESIGN . . . chains may readily be assembled or disassembled with use of small hand tools.



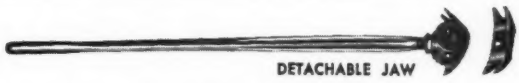
6-IN-ROW RIPPER HEAD

Using 6 renewable independently adjusted Cutterbars, with all 6 Chains similar in kerf and lacing arrangement for interchangeability. All 6 sprockets interchangeable. Improved design head drive shaft and sprocket assembly using 2 piece sprockets to maintain extreme tension to the shaft.

These are only a few of the features and advantages in this modern Ripper Head for Continuous Mining. Ask a Bowdil representative or write for more detailed information.

Also:

"No-Bend-'em" Spike Pullers



DETACHABLE JAW

"Changeable-Points" Hand Picks

"No-Tools-Needed" Rope Sockets

GET IN TOUCH WITH THESE BOWDIL MEN:

J. M. (Joe) BLASCO
N. Liberty Avenue
Perryopolis, Penn.
Tel. Redfield 62575

D. L. (Dave) BOWMAN
425 Briar Ave.
North Canton, Ohio
Tel. HY 98439

E. D. (Ed) CAUDILL
Box 132
Danville, West Virginia
Tel. 810

A. J. LEACH
Sandlick Road
Whitesburg, Kentucky
Tel. 2232

RANDALL A. LEACH
1004 E. St. Louis St.
West Frankfort, Ill.
Tel. 675

WM. (Bill) RADCLIFFE
761 Steel St.
Denver, Colorado
Tel. EA 27151

C. W. (Pete) WEISBURN
E. Carrollton St.
Magnolia, Ohio
Tel. UN 62166

THE BOWDIL COMPANY • 1200 BOYLAN AVE. • CANTON 7, OHIO
WANT SOMETHING SPECIAL? TEL. GLendale 67176

Bowdil has the staff and facilities for economical designing and custom-building.

BOWDIL

ALWAYS *RIGHT* ON THE JOB

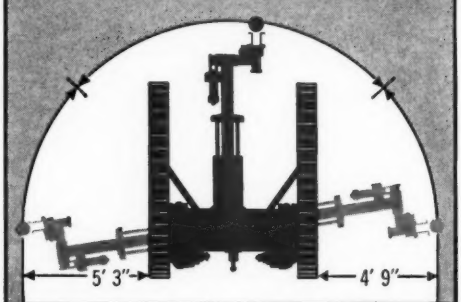
Unmatched versatility . . . drill boom is swung at right angles to tracks and drill carriage tilted inward for steeply sloped conditions.

The all new Chicago Pneumatic G-900 Tracdril is the culmination of 5 years of research and wide field experience. This self-propelled drilling unit is maneuverable, rugged and productive . . . a real *"drillers drill."* Extra large drilling radius because of its 180° horizontal boom swing and dual controls on turret and boom end for quick, accurate positioning of boom and drill carriage give the driller exceptional flexibility.
With the sensational 4½" Deep Hole Drill, it quickly sinks 3" holes up to 75 feet.

6 MAJOR EXCLUSIVES OF CP TRACDRILS

❶ **"Boarding house reach"** lets the drill carriage stretch out 63" beyond tracks to drill true verticals alongside the unit. ❷ **Extra-long Oliver tracks,** specially designed, provide stabilizing ground contact of 1350 square inches. ❸ **Sure-footedness and maximum traction** are assured with five lower track wheels. ❹ **Seven labor-saving hydraulic cylinders** ease driller's muscle work, give fluid-smooth action. ❺ **Two sets of grouped controls,** at turret and boom end, save time and steps for driller, boost footage. ❻ **"Dead man" automatic brakes** that slam on when tramming throttle is closed, locking unit on steepest slopes or bad ground.

NO EQUAL FOR DRILL PATTERN COVERAGE



- **Full 180° Ground Coverage . . . right or left. New G-900 drills true verticals at 90° angle to tracks.**

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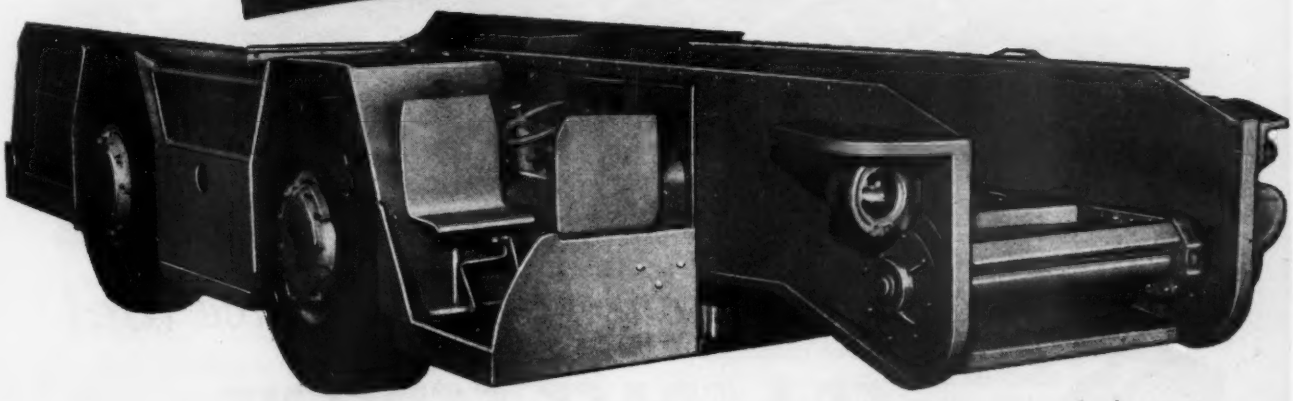

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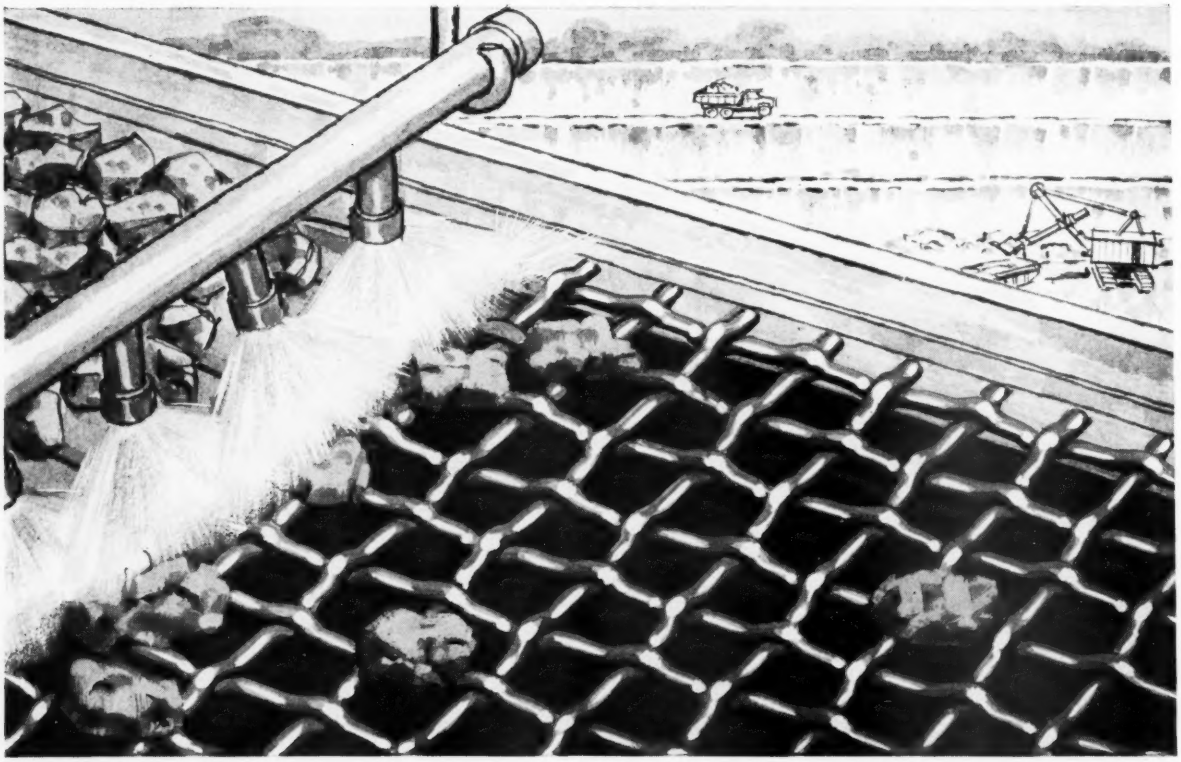

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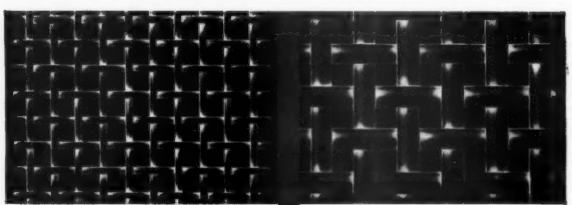

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Editorials

MINING CONGRESS JOURNAL

ROBERT W. VAN EVERA, Editor

October 1960

Declaration of Policy

The big AMC Mining Show in Las Vegas will soon be history. A full report of the mammoth exposition, the convention sessions—devoted to both policy and operating problems—and other convention activities will appear in our November issue.

Among the major features of these meetings are the deliberations of the Resolutions Committee, which are crystallized in a Declaration of Policy setting forth in a forceful, straightforward manner the industry's position on matters of public policy. Included are such subjects as National Minerals Policy, Taxation, Safety, Labor Relations, Public Lands, Water and Air Pollution, Solid Fuels, Uranium, Monetary Policy, Mine Financing and others.

These statements of policy are submitted to the full Convention for consideration, and when adopted, reflect the views of the entire industry on these important matters.

The industry has never been known to "pull its punch," and this year's declaration will again command respect as a sound and constructive statement of principles which should be applied in legislation and administrative action affecting the mining industry. It will serve as a guide in conducting the affairs of the American Mining Congress in the coming year, and will contribute to a better understanding of mining's problems and needs by the general public as well as by those having responsibility in governmental matters.

The full text of this important document will be published in our post-convention story next month. It merits your serious study.

Treasures of the Deep

The article on pages 48 to 53 of this issue entitled "Mineral Resources on the Ocean Floor" describes an intriguing phase of research involved in the never-ending search for new sources of minerals.

The United States has become in varying degrees dependent on other nations for its supply of many essential commodities. But the day might come when these foreign sources, because of changing international politics and rising nationalism, will prove unreliable and force us to turn back to deposits within our own boundaries or wherever else our ingenuity can procure the minerals needed for American industry.

This is the basis for the cooperative research program of the Institute of Marine Resources at the University of California, under which intensive study is being given to the surface of the earth which lies under the oceans.

Already several underseas mineral enterprises have advanced beyond the research stage. Sulphur, oil, gas, coal and iron ore are being produced from deposits which lie under the continental shelf in relatively shallow water surrounding the North American continent. Also, a number of "heavy minerals" are being recovered from beach sands—a form of mining that has been carried on for more than fifty years.

Considering our nation's huge expenditures for space research, we might conceivably develop our knowledge of the surface of the moon before we obtain accurate information about a major part of the earth's own surface—the ocean floor.

As the author has pointed out, research that holds promise of economically practical results of benefit to our basic industries should be supported. In the case of minerals on the ocean floor, our industry could be significantly affected, and it would seem wise for mining men to watch the results of such research with keen interest.

A Sensible Approach

The U. S. Bureau of Mines has taken a realistic approach to present-day coal mining problems by its amendment of Schedule 2F to make longer trailing cables permissible.

With mining becoming more concentrated, and equipment becoming more powerful, the working face in a modern coal mine advances at a considerably faster rate than it did just a few short years ago. Thus the absolute limit of 500 ft, as formerly provided by Bureau regulations, became a hindrance to efficient operations in some mining systems. The new amendment allows trailing cable lengths of up to 1000 ft if certain requirements having to do with short-circuit protection, current-carrying capacity and cable resistance are met.

We believe this is a safe and sensible solution, and commend the Bureau for its constructive approach to the problem.

Slusher Operation on Narrow Veins Solves Stoping Problem

Extreme narrow widths of shrinkage stopes and unusual characteristics of broken ore have necessitated the use of scrapers to draw ore from the top of ore piles instead of the bottom

By WILLIAM H. HARRISON, JR.
General Mine Superintendent,
Fairview Mine
Aluminum Company of America

In the Fairview mine of Aluminum Co. of America in Hardin County, Ill., fluorite occurs with calcite and minor amounts of lead and zinc sulphides in a fissure type vein in sedimentary rocks of Mississippian Age. The normal fault zone (Blue Diggings) strikes in a general northeast-southwest direction and dips steeply to the southeast, with a branch fault (Argo) that strikes generally north-south and dips west. Thickness of the veins vary irregularly from very narrow veinlets up to mineralized zones 20 to 25 ft in width. The average width of fluorspar stoped is about 42 in. and the minimum width is ten in.

Shrinkage Stoping Suitable Under Existing Conditions

Although there has been considerable displacement on the faults, the wall rock has been relatively undisturbed and will stand unsupported in the stopes for long periods of time. A little slabbing may occur locally, but it is unimportant.

There is very little alteration of the wall rock by thermal solutions. However, the limestone hanging wall usually contains a higher percentage of silica within 18 in. of the faults. There is evidence of post-mineral movement locally in and across the mineralized fissures, but its effect upon the strength of the ore and rock is negligible.

Five conditions have made the deposit suitable for shrinkage stoping: (1) relatively little disturbance of the wall rock by pre-mineral faulting, (2) very little alteration by mineralizing solutions, (3) small amount of post-mineral movement, (4) a structurally strong vein complex and wall rock, and (5) the steep dip.

The character of the vein material after it has been blasted is a critical factor in mine operation. Both the fluorite and the calcite tend to break into an aggregate which is composed predominately of fine angular particles of these two minerals, together with some wall rock if the blast breaks into the walls of the deposit.

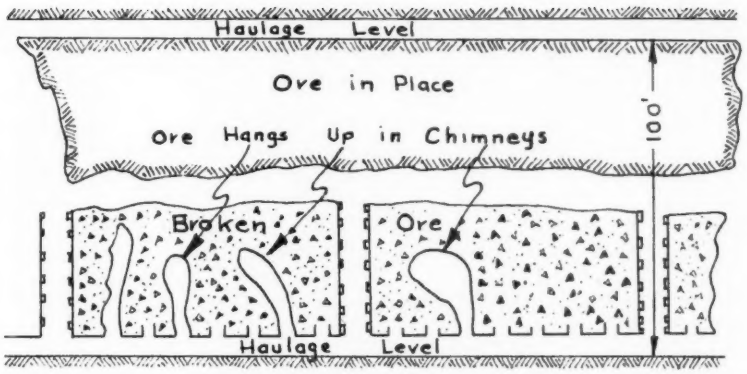
In the narrow widths, below three ft and down to the ten in. minimum, it is necessary to take sufficient footwall rock to keep the stope opening to the needed three ft width. These extremely narrow widths are sometimes carried for short distances, both

horizontally and vertically, between two known ore lenses of greater width to provide a continuity of the stoping operation.

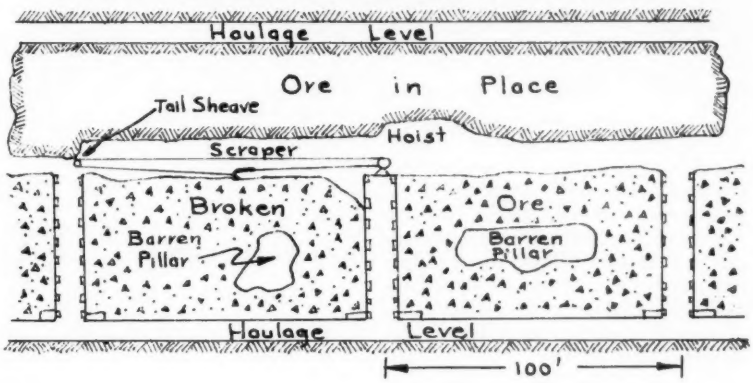
Broken Ore Compacts When Wetted

On blasting, the ore breaks very finely because of the softness, friability, and the cleavage of its constituent minerals. The resulting fine material, when mixed with drill-water, packs readily into a compact mass. The angle of repose of the water-packed broken ore in a narrow stope is very steep, approaching the vertical.

When the mine was reopened in 1941 and stoping resumed, drifts were driven to develop the ore body for mining by shrinkage stoping. Manways were spaced 100 to 200 ft apart and chutes were spaced every 20 ft along the main haulageways in the stoping areas. Mining was commenced from the sill floors without leaving pillars and the bottoms of the stopes were floored with three-in. oak lagging on stull timbers. But even with a steep footwall, the ore would not draw. Excessive mucking was required to remove the ore from the stopes to make headroom to drill the stope backs. The broken ore had a tendency to draw into very steep sided chimneys, and these chimneys sometimes refused to pull through to the top except in a slow and erratic manner (see figure 1).



Figs. 1, 2. Conventional shrinkage methods failed because ore hung up in chimneys (above). The problem was remedied by eliminating numerous chutes and installing double-drum slushers adjacent to raises to scrape into chutes as shown (below)



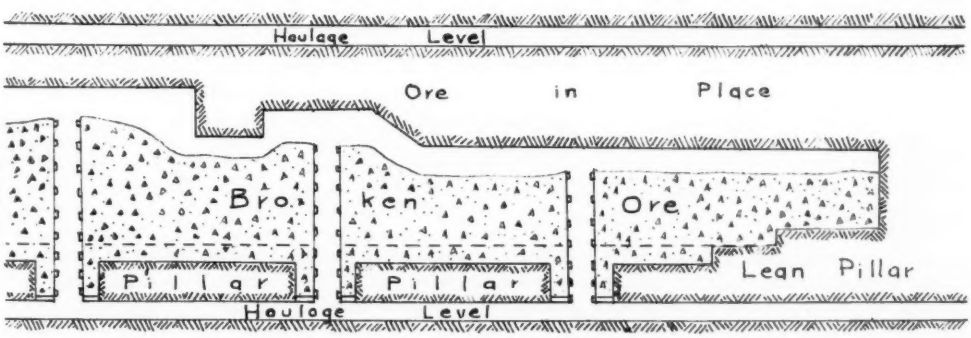


Fig. 3. Shrinkage stoping using sublevel method shows how sublevels were extended to follow ore overlying lean material

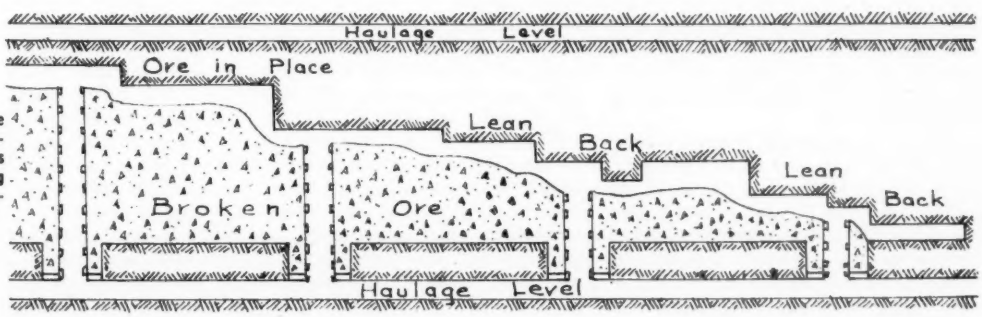


Fig. 4. Shrinkage stoping using sublevel method shows system of retreating as ore becomes uneconomical

Adaptation of slushing to shrinkage stoping has improved safety in the stopes, increased efficiency and flexibility, and reduced the cost per ton of ore mined

Working Conditions Were Hazardous

Careful control of ore drawing and the exchange of information regarding chute and bin conditions between the trammers and the miners were essential to prevent accidents, for the miners had no way of knowing from the appearance of the muck alone whether it was solid or contained cavities. To minimize the danger these conditions presented, long boards and sections of pipe were kept in each stope to be placed over the suspected site of a breakthrough. Draw control sheets of each stope were kept to itemize the number of cars drawn from each chute and to show whether the muck above the chute had pulled through to the top of the broken ore. The succeeding shift of stope miners were warned of the working conditions prevailing in their stope.

The interval between chutes was reduced to 12 ft, but this change failed to facilitate movement of the broken ore. When a stope failed to draw properly, it was necessary to shut it down completely until the compacted ore could be broken loose either by the use of water or explosives or both. This failure to draw usually resulted in the stope being overdrawn, and staging was required to enable the crews to drill the backs. By the time enough ore had been drilled and blasted to fill this hole, the broken muck had been repacked into a tightly compacted mass.

Many attempts were made to solve this problem. A car of ore per shift was drawn from each chute in an effort to keep the muck loose and running. Miner shifts were doubled in the stopes to accelerate drilling and blasting and to handle the more frequent ore withdrawals that were then necessary. Drilling with both an excess of water and a small amount of water were tested, but neither of these methods was successful. It seemed that the quantity of drill-water required to compact the broken muck was small, and a larger quantity did not materially change conditions.

Mining Method Modified

Since none of the practices which were tried overcame the existing problems, it was decided to adapt scrapers to the shrinkage method of mining. The proposed plan required the use of lined manways 100 ft apart with a chute immediately on either side of the manway (figure 2).

Small scraper hoists were installed on stull timbers at the top of the manways. From this position, the miners nominally scraped ore from 100 ft on either side of the manway into the chutes. In actual operation, because the chutes were 100 ft apart, the scraper operators slushed 50 ft on each side of a manway and moved to the next manway and repeated. This frequent moving paid off in more muck moved due to the shorter scraper haul. The method eliminated six or seven chutes for each 100 ft of stope length because the ore was scraped from the top of the broken pile instead of being drawn from the bottom. Enough ore was removed after each blast to allow about seven ft of headroom for drilling.

The miners liked the slusher stopes because the broken ore formed a solid column of material under them and because they no longer feared the possibility of working over a concealed cavity. This method of stoping also had a tendency to keep the back of the stope level longitudinally, and the irregularity in height, usually found due to wider, more easily broken material, did not exist.

After the stope was completed to the next level above, the remaining broken ore was removed in successive slices downward from the top of the stope. The slushing crew became a stope robbing crew and followed the ore down, placing stulls or roof bolts as needed to control the walls and to keep their operation safe. They also drilled and blasted any small amounts of ore left in previous operations. Final stope cleanup showed that about ten percent more ore was removed than was estimated as originally broken.

Several difficulties were encountered. The stope widths were as narrow as 30 in., and the footwall and hanging wall were very irregular in many places. The vein itself was quite sinuous, and the slusher operator could not always view his scraper even a short distance from his station, but in spite of these obstacles the plan proved very successful. The scrapers worked well even around a curving footwall and the narrow stopes were slushed as easily as the wider ones.

Scrapers Add Flexibility to Operations

It has been found that the method works as well from a sublevel as it did from floored stulls and that scrapers can be used to remove blasted muck from the sublevels (figure 3). The stoping method has been used to enlarge the stope in length to extract good grade vein material for 100 ft beyond the last draw point, and, conversely, the stope has been shortened as vein material turned to rock (figure 4). A barren area that had been surrounded by good mineable ore can be left and the ore immediately above mined by resubleveling over it (figure 2). Use of scrapers has provided flexibility in the mining method that shrinkage stoping usually lacks.

One small air hoist will service about three 100-ft stopes or 400 linear ft of the same stope. A slushing unit consists of an Ingersoll-Rand A5NN-OH, double drum, utility hoist, and a 26-in. curved blade, Westeeco, open hoe scraper. With a double clutch hoist, it is possible to lift the scraper when it hangs on irregularities of the stope walls or picks up too heavy a load.

The adaptation of slushing to shrinkage stoping in this mine has improved the safety of operating conditions in stopes, increased efficiency and flexibility, and reduced considerably the cost per ton of ore mined.

Both the theory and the actual experiments indicate the practicability of using sonar techniques to detect hidden unconformities in coal mine roof

Equipment used by the Bureau to determine whether sonic techniques could be applied successfully to detect hidden unconformities in coal mine roof

Sonar Exploration of Coal Mine Roof Strata

By CHARLES E. MONGAN, JR.
Consulting Physicist
and THOMAS C. MILLER
Mining Health & Safety Engineer
Roof Control Research Group
U. S. Bureau of Mines

THE problem of roof control in the coal mining industry is of major importance since more than 50 percent of all coal mine fatalities and 25 percent of the non-fatal serious injuries are the result of falls of roof, face, or ribs. It is estimated that more than $128,000,000 was spent for the support of roof in 1958.

No positive method has been devised for the determination of mine roof conditions not readily discernible by visual inspection. Because of this such unconformities as faults, fissures, rolls, kettle bottoms (concealed) and other inconsistencies remain hidden until movement of the roof reveals them—unfortunately, many times as fatal or serious accidents.

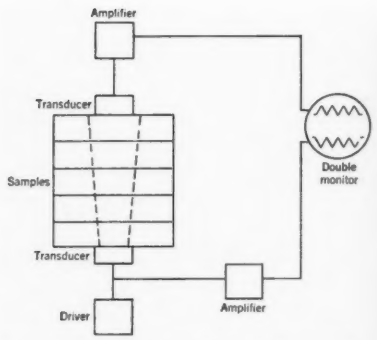
The geology associated with this problem has been extensively studied. In most cases the bedding planes of coal seams are horizontal. Above the coal are layers of clay, shale, or sandstone.

Bureau Launches Investigation of Sonar Techniques

In June 1950 at the suggestion of Edward Thomas, chief of the Roof Control Research Group of the U. S. Bureau of Mines, an investigation was instituted to determine whether sonic techniques could be applied successfully to detect these hidden unconformities common in coal mine roof.

Studies carried out over an extensive period by the Roof Control Research Group of the Bureau of Mines have shown the importance of devices and techniques which would allow the exploration, in place, of questionable roof.

A requirement thus arises for a de-



Laboratory set-up for a transmission experiment through sample. The transducers shown emit sonic energy in the form of a beam. Characteristics of the beam are determined by the frequency which the transducer is designed to accept for optimum operation and by the physical dimensions of the face

vice and method of test. In order to design such equipment, the following requirements must be met:

1. Such a device should be light and portable.
2. It should have low power demands.
3. It should be safe in the environment of an operating mine.
4. Regular mine personnel should be able to operate it, read and interpret the results.

Numerous attempts have been made to design roof testing devices using micro-waves of high frequency and in the other extreme, using seismic-waves of low frequency and extremely high power. These efforts have generally proven unsatisfactory, due in the first instance, to the lack of penetration of the pressure wave and hence a lack of accurate definition; in the second instance, extremely great penetration of the pressure wave which permits only the definition of variations of massive rock formations. Therefore, neither of these methods provide the detail needed to resolve the problem described.

This report describes the approach and experimental work done to accomplish these objectives, together with an evaluation of the status of the project.

Roof Testing Device Designed for Use Underground

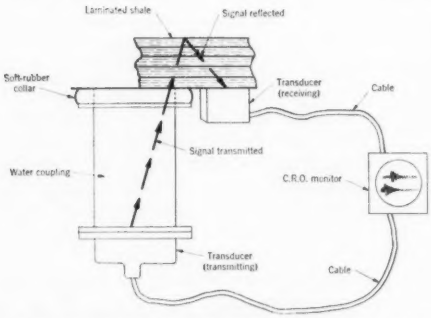
A study has been made of the application of sonar techniques to roof control problems. Preliminary tests were made using layers of roof rock in the laboratory. To apply the experience thus obtained, a unit was designed and constructed for use underground.

The term "sonar technique" refers to the system of generating a sonic or ultrasonic beam of waves, shaping and directing this beam, introducing the beam into a medium to be studied and examining any returning waves with a view of inferring the nature of the material traversed by the waves and the presence of interfaces or obstacles in the medium.

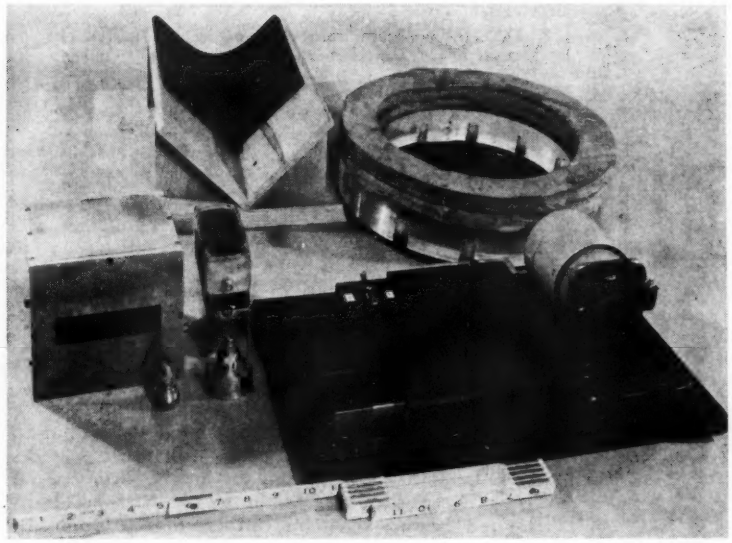
Each step of the system involves a basic physical process. In the actual apparatus, a choice of the parameters is necessary. In order to explain the choices made and the over-all performance of the experimental system, the various physical processes are discussed in turn.

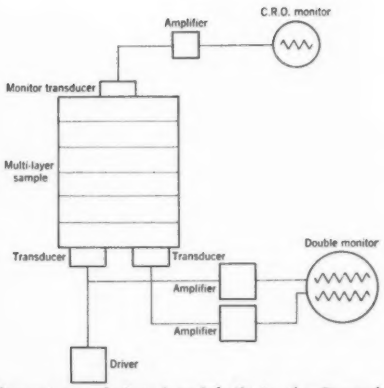
Transducer Converts Electrical Input Into Sonic Output

The convenient way to generate a sonic or ultrasonic wave is by means of a transducer which is a device that contains either piezoelectric material or magnetostrictive material and converts an electrical input into a sonic output; also, sonic impulses may be received by a transducer and converted to electrical impulses which may be reproduced on a Cathode Ray Oscilloscope for observation. There are other methods which are occasionally used; however, in these in-



Set-up for monitoring reflected impulses. From the results obtained it was decided that an increase in output power of the transmitter was desirable and that it would be necessary to explore the feasibility of using frequencies other than the 12 and 70 kilocycles being employed





Equipment was designed and built in the Bureau's laboratory to provide a power output of up to 1.5 kw and of frequencies from 1 cycle to 100 kilocycles. A number of transducers capable of operating at several frequencies were also assembled, and monitor transducers were provided. Above views show a block diagram of the equipment as well as a picture of the equipment built in the laboratory

vestigations both the piezoelectric and magnetrostrictive type transducers were used.

The characteristics of the wave, i.e., the frequency, the amplitude, and the pulse length, are determined by the characteristics of the electrical wave which is the output to the transducer. In this manner, by controlling the electronic transmitter, the characteristics of the sonic wave are obtained.

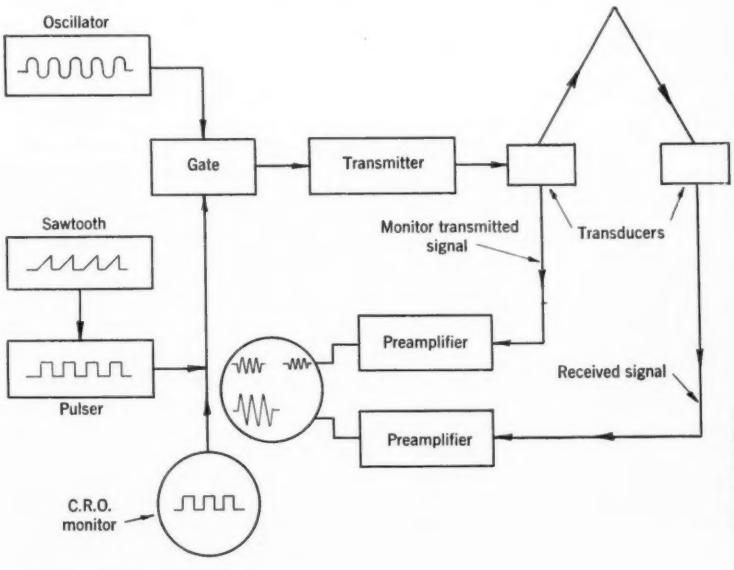
The transducer emits sonic energy in the form of a beam somewhat like a searchlight. The characteristics of the beam are determined by the design of the transducer—more specifically by the frequency which it is designed to accept for optimum operation and by the physical dimensions of the face. For most purposes it is desirable to have the energy output confined to a relatively narrow beam. In this case, a conical angle of 20° is being considered.

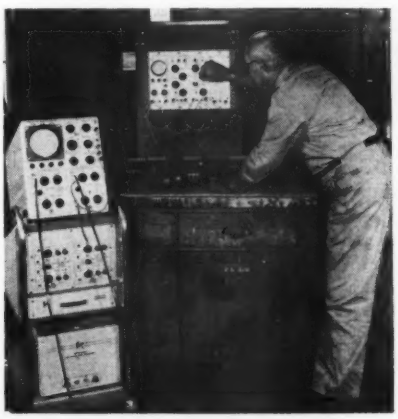
Impedance Equals Product of Density and Sound Velocity

The propagation of the wave is fixed by the elastic properties of the medium through which it is projected. The modulus of elasticity and the density determine the sound velocity. The impedance, which is the product of density and sound velocity, plays an important role in propagation studies. If the impedance on one side of the interface is different from that of the other side, the wave will be reflected. If the impedance is alike, the wave will be transmitted without reflection. Notice that the criterion applies to the product of the velocity and the density. The greater the difference in impedance on the two sides, the larger the reflected signal.

Attenuation Coefficient Varies with Frequency

As a sonic wave proceeds through rock the intensity of the wave decreases due to two principal causes. In the first place, due to geometric spreading the intensity becomes less; and secondly, there is a decrease in intensity due to the losses in the propagation itself which can be con-





(Above) Transmitter built in laboratory and instrumentation purchased for project. (Left) Block diagram of equipment used in experiments. Using the laboratory-built apparatus, further experiments were conducted at various frequencies and at power output from 100 watts to 1.5 kw. Results indicated that lower frequencies and higher power output produced results of satisfactory accuracy

Table I. Velocity of propagation of sound in fps in various rocks

Rock	*Ref. I*	*Ref. II*	*Ref. III*	*Ref. IV*
Coal	3773			
54.1 Shale		7400		
54.2 Siltstone		5300		
54.3 Sandstone		9600		
53.2 Diorite		18300	15100	
55.6 Granite		10400	12300	
Sandstone 1			10300	
Sandstone 2			10800	
Sandstone 3			3100	
Marly Clay				10300
Bituminous Sandstone				12900
Argillaceous Sandstone				10700

I. Report by the Technical Mission, National Coal Board, p. 15.
II. U. S. Bureau of Mines R.I. 5244, p. 4.
III. "Sonic Wave in Mine Rocks and its Related Application" by T. Suzuki, K. Sasaki, N. Yamakado and Z. Siohara, Mining and Safety Resources Research Institute—Japan August 1958.
IV. Miller—L.C. 833, Dept. of Scientific and Industrial Research.

Table II. Impedance, which is the product of density and sound velocity, has been calculated for different materials

Material	*C* *Velocity Cm/S*	*ρ* *Density*	*Z* *Impedance*
Coal	115 × 1000	1.35	155 × 1000
Slate	162 × 1000	2.76	446 × 1000
Shale	226 × 1000	2.72	615 × 1000
Sandstone	293 × 1000	2.73	800 × 1000

sidered analogous to friction. This latter loss is referred to as attenuation. The attenuation coefficient is a measure of the loss. It is different for different materials and also varies as function of frequency of the same material. In general the attenuation coefficient increases rapidly with increase in frequency.

Data on the values of attenuation coefficients for different rocks at different frequencies are not readily available, but there is reason to believe that the attenuation coefficient of the rocks which occur in the roof of coal mines would be of the order of magnitude of one to two decibels per meter of travel.

Extensive studies of the mechanical properties of rocks, including the velocity of sound propagation, have been carried out by the Bureau of Mines in its laboratories in College Park, Md. The results of these measurements have been published in a series of reports. Values of the velocities from these reports have been collected in table 1.

From the point of view of this research, it is desirable to know the attenuation coefficient referred to meter of travel. These quantities may be inferred from the specific damping coefficient which are collected in U. S. Bureau of Mines Report of Investigations 5251—"A Study of the Air and Rock Vibrations Produced by Impact Testing of Mine Roof," by P. M. Summerfield. These values refer to only a limited band of frequencies.

The density of the rock is another important characteristic. The densities are known.

It is possible, employing suitable instrumentation, to observe the reflections relative to time of transit, so with a knowledge of the velocity of propagation in the media, to actually measure the thickness of the specimen being observed; hence, the location of the joint or separation. This has been done both in the laboratory and in underground experiments and checked against actual measurements.

Measurements of the attenuation have been made at certain frequencies. From these values, the impedances for coal, shale, and sandstone can be calculated as shown in table 2. If certain assumptions are made, which are reasonable by analogy, but not physically checked, estimates can be made of the attenuation as a function of frequency.

The reflectivity of various interfaces for normal incidence has been calculated. The reflectivities show that fraction of the incident energy which is reflected.

Lower Frequencies, Higher Power Output Prove Best

A survey of published literature reveals only limited data concerning velocities, impedances, and attenuation which were directly applicable to the problem, therefore, it was decided to make a preliminary series of experiments which would provide a qualitative background for the method.

Samples of slabs of coal, shale, and sandstone were assembled. These specimens were of various thicknesses.

Two sonic transmitter-receivers were obtained together with matching transducers.

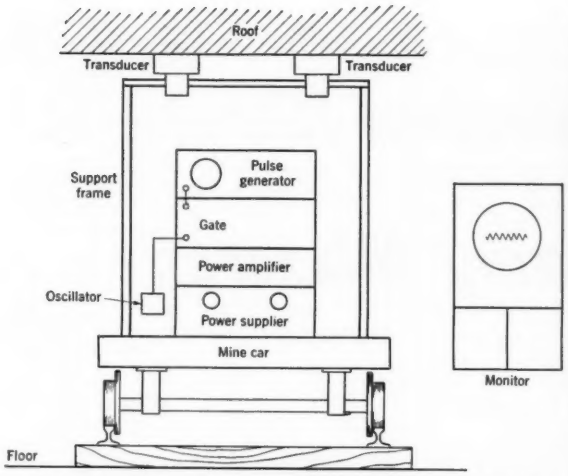
The apparatus was set up in the laboratory. This allowed transmission through the sample. The various materials were inserted and the transmission observed. In this manner, using various thicknesses of materials, a preliminary view was obtained of the velocity of sound propagation in the various media using frequencies of 12 kilocycles and 70 kilocycles. A qualitative estimate of the attenuation at various other frequencies was also obtained. With this qualitative picture available, work proceeded to more exact tests.

The apparatus was set up to allow the monitoring of reflected impulses. From the results obtained it was decided that an increase in output power of the transmitter was desirable and further, that it would be necessary to explore the feasibility of using other frequencies. Equipment was designed and built in the Bureau's laboratory to provide a power output of up to 1.5 kw and of frequencies from 1 cycle to 100 kilocycles. A number of transducers were also assembled, capable of operating at several frequencies; monitor transducers were also provided.

Using the laboratory built apparatus, further experiments were conducted at various frequencies and at power output from 100 watts to 1.5 kw. Using properly tuned transducers, tests were run with transmission through specimen samples of coal, shale, and sandstone. Tests as to reflectivity of voids and discontinuities were also conducted. Various different power outputs and wave lengths were used which indicated that lower frequencies and higher power output produced results of satisfactory accuracy. In the course of this phase of the investigation, some 131 tests were run and photographs made of the outgoing and reflected pulses reproduced on a cathode ray oscilloscope.

In the course of these experiments, occasion was taken to measure the time of transit of the signal through the rock. Knowing the thickness of the sample, the velocity of propagation could be calculated. The result was in agreement with values in the literature published.

The velocity of propagation of sound in roof rocks is high, the distances of interest in this problem are relatively short; therefore, the time intervals which have to be measured are extremely short. In fact, these time intervals are comparable with the duration of a powerful pulse; therefore, it is experimentally con-



Set-up for underground tests. Preliminary experiments showed qualitatively that a signal could easily be passed through 73-in. material

venient to use two transducers, one for sending and the other for receiving.

Underground Tests Indicate Practicability of Method

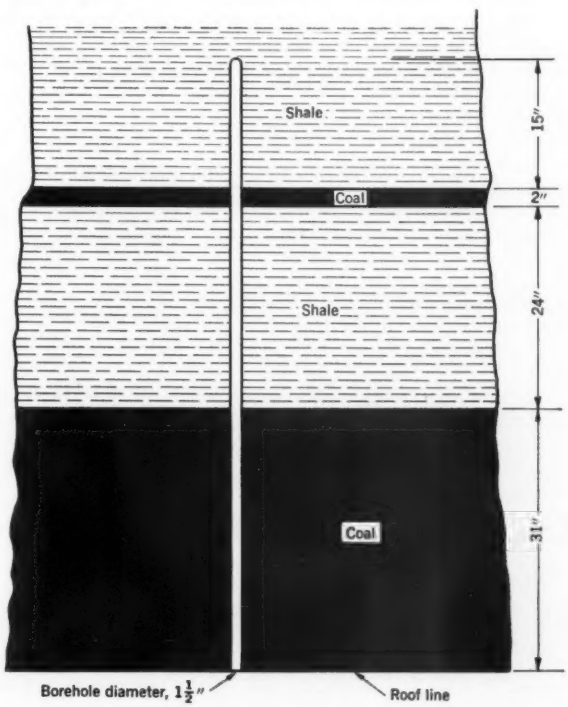
For the underground tests, an apparatus was constructed. It consisted of two units, one of which was mounted on a mine car. The transducers were mounted on a support frame, also on the mine car, which could be so adjusted that the transducers pressed against or were coupled to the roof. One transducer served as a transmitter, the other operated as a receiver. The transmitting transducer was driven by an electronic stack consisting of a power supply, power amplifier, amplifier gate, pulse generator gate, oscillator and monitor. This apparatus permits the use of a wide frequency band (5–100 kilocycles), variable pulse lengths (0.1–100 microseconds), and a variable power output (up to 3 kw).

In operation, the mine car was blocked at a chosen location. Then the monitor was set up beside it. The equipment then was operated so that the returning pulses (echoes) appeared on the cathode ray oscilloscope. Photographs were made of the screen of the oscilloscope.

Later a borehole was made at the same location. The log of the borehole could be compared with the photograph of the returned signal.

The preliminary experiments showed qualitatively that a signal could easily be passed through 73-in. material. (This was checked by the borehole.) These experiments also showed that the attenuation increased rapidly with the frequency. The sound velocities measured agreed with those in the available literature. The actual times of transit for the signals were short and of an order of 100 microseconds. These results pointed to the advantages of a two transducer system with low frequency, short pulse length and high power characteristics.

Both the theory and the actual experiments indicate the practicability of the method. The tests in the Bureau's experimental mine confirm the impression of the validity and usefulness of the method. Much lighter and more compact apparatus is desirable. The suitability of a design for use in a mine having gas or a dusty environment has also been considered. No particular difficulties have been discovered; however, the details of the design require much more work.



After the underground tests were run using the sonar method, a borehole was drilled to check the results

Innovations in Ammonium Nitrate Blasting Mixtures*

By DONALD M. STROMQUIST
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To fully realize the economies of using ammonium nitrate-fuel oil mixtures, many companies have developed bulk storage and handling systems especially suited to their operations

USE of ammonium nitrate and fuel oil mixtures in open pit blasting became widespread after the disclosure of the use of ammonium nitrate and 1 to 12 percent carbon black (in polyethylene tubes) as a large diameter blasting agent.[1]

From the use of a solid carbonaceous organic material, which was employed to oxygen balance the ammonium nitrate used, it proved to be a simple step to substitute diesel oil which is readily available, easier to handle, and produces a more uniform mixture. It is difficult to establish where or when fuel oil was first used. However, ample evidence of its use was reported in the literature following the initial patent disclosure, but no specific patents on the ammonium nitrate-fuel oil process. This indicates the idea was probably evolved at several places more or less at the same time.

Ammonium nitrate-fuel oil mixtures have taken over the major portion of open pit blasting in this country and others, and is often used to replace condensed explosives on a pound-for-pound basis. While it has its limitations, such as low water and moisture resistance, coupled with less efficient performance in small diameter holes, these are small matters compared to the great economies to be gained with its use.

Blasting Agent Defined

At some time or another the reader may have seen copy out of context similar to the statement "ammonium nitrate is the berries for our blasting." Statements such as this make it important to clearly point out just what material is under discussion.

When a combustible material is added to and mixed with ammonium nitrate, it is no longer a fertilizer. Ammonium nitrate in such a mixture serves as an oxidizing agent and is so classified by governmental regulatory bodies such as the Interstate Commerce Commission. Ammonium nitrate mixed with the proper amount and kind of a combustible material is a blasting agent.

While ammonium nitrate-fuel oil mixtures are classed as blasting

Loading blast holes from a 4½ cu yd mobile concrete mixer. Note fuel oil storage tank above and between cab and mixer drum

** This article is a resume of procedures which have been reported for preparing ammonium nitrate-fuel oil mixtures, but in no case have we (the author) attempted to evaluate the safety qualifications of the methods nor are we in a position to assess them. The reader is referred to the various references quoted for safety precautions to be taken.*

agents, they are less sensitive than the so-called conventional condensed explosives. According to the National Fire Protection Association, a blasting agent "shall mean any material or mixture, consisting of a fuel and oxidizer, intended for blasting, not otherwise classified as an explosive and in which none of the ingredients are classified as an explosive, provided that the finished product, as mixed and packaged for use or shipment, cannot be detonated by means of a #8 test blasting cap when unconfined."

All of these mixed blasting agents, whether premixed or field mixed, should be stored, transported and handled in accordance with the recommendations of the National Fire Protection Association Bulletin #495, July 1959, and Bureau of Mines information circular #7988 Tentative Safety Recommendation for Field Mixed Ammonium Nitrate Blasting Agents.

Let us now describe what some firms have done to advance and streamline the use of ammonium nitrate-fuel oil mixtures for their own special purposes. Each development is more or less specialized and tailored to the individual firm's use, and for this reason the operator sometimes uses his own ingenuity to branch out and improve his own use pattern with due regard to safety factors.

The pre-mixed ammonium nitrate-carbonaceous mixtures are available, but a number of mining companies report that 2 to 2.5 cents per lb premium will allow for substantial expenditures to be made in order to switch from a purchased pre-mixed product.

Ammonium Nitrate Bulk Handling Systems

Many operators use ammonium nitrate in bags and upon adding diesel oil or other combustible materials depend on natural diffusion to accomplish the necessary mixing of the ammonium nitrate and oil.

Several firms have taken advantage of the differential in bagged and bulk ammonium nitrate prices and have put in bulk handling systems. This differential is not the only saving gained, since all of these users report a reduction in labor force plus increased efficiency in operation due to further refinements, such as development of bulk hole loaders. For proper handling procedures covering ammonium nitrate, prior to mixing with carbonaceous material, refer to Manual A-10 published by Manufacturing Chemists' Association.

Bulk hole loader in position and about ready to load a hole. An air winch lifts the truck box so that dry ammonium nitrate will fall into the measuring hopper

One southwestern Utah firm reportedly receives its nitrate in a bulk hopper car that is spotted over an under-the-track augur for unloading. From the augur, the ammonium nitrate is conveyed to a bucket elevator which lifts it to the top of a wooden, enclosed, bulk storage bin. This bin is so elevated on supporting members that the bulk hole loading truck can be driven under it and be filled by gravity.

All of the ammonium nitrate is handled dry in the truck, is dispensed by gravity into a volumetric measuring container, falls at the proper time into the borehole and as it falls is sprayed with a metered amount of oil. This firm uses an integral air winch to lift the truck box containing the ammonium nitrate so that it will fall into the measuring container.

Mobile Concrete Mixers Make Mixes in Ten Minutes

Another southwestern Utah company has purchased two modified, mobile 4½ yd concrete mixers. These have been lined with several vinyl coatings, and an oil tank and distribution system has been added to the truck. The oil is sprayed into the rotating mass of ammonium nitrate, and

Loading ammonium nitrate into a hole-loading truck by gravity from wooden storage bin

A bucket elevator fills this bulk storage bin with ammonium nitrate from a hopper car spotted over an under-the-track augur

company personnel state that excellent mixes are obtained in less than 10 minutes.

Holes are loaded from the familiar chute at the end of the truck, and levels in the boreholes are checked by sounding with a weighted tape measure. Loading is accomplished easily and quickly, and proper mixing of oil and ammonium nitrate is assured. The trucks never leave the property of the firm and, at all stages, the materials are handled with all due safety precautions to prevent sparking or anything else that might prematurely ignite the mixture.

A Nevada company has constructed a wooden bulk storage bin in such a location that full advantage of gravity can be utilized, from delivery of the product to end use.

Ammonium nitrate arrives in bulk in hopper-bottom trucks which pull over the top of the bin and discharge the load in minutes. Since the bin is constructed on a slope, the hole loading truck can drive beneath the bin at the next lower level to obtain its load by gravity. The hole loader is constructed internally with sloped surfaces so that the ammonium nitrate falls by gravity when desired into an attached measuring container, out of the container against a metered spray of oil and into the borehole.

Special Truck Unloaded Pneumatically

At several operations in the East and on the Mesabi Range a specially fabricated truck for dispensing ammonium nitrate-oil mixtures is used. It is rather sophisticated as borehole trucks go and naturally is much more expensive.

The truck is an adaptation of a bulk fertilizer spreader truck that consisted of a bulk bin, an augur, and a disc spreader. They have retained the bin and augur, removed the disc spreader and added a star feeder to measure the product, an oil metering system and tank, and a long hose in which the nitrate-oil mixture is boosted along by air. This truck has the advantage of allowing the operator to load several holes from one location by just moving the hose from hole to hole. This would appear to be an advantage for rough terrain, but the added cost of this equipment should be weighed against the simpler hole loaders which require placement directly over the borehole.

One user is said to be employing this type of truck in Canada but is pre-mixing the ammonium nitrate and oil in a batch mixer before it is loaded into the borehole loading truck.[2] In the use of mobile equipment suitable precautions are taken to prevent pre-ignition.

The use of storage bins has been discussed and so far only elevated wooden bins have been mentioned. Manufacturers believe that a steel bin with a satisfactory coating, such as those used in grain storage, would be excellent for ammonium nitrate storage.

Others have used the methods employed by fertilizer dealers, who place the ammonium nitrate on the floor of a warehouse, build three walls around it and either pay-loads or augurs it out to a truck.

Blasting Mixture Additives

In addition to TNT being mixed with ammonium nitrate at one location, some companies are reported to have used both molasses[3] and sugar and water[4] mixed with ammonium nitrate for blasting. Although these practices have been publicized, it does not seem they have been used too widely in the mining industry. However, people who are successfully using these mixtures are in a better position to discuss their advantages.

Additives to ammonium nitrate probably reach their peak when the new and novel slurry explosives are considered.[5] Developed by Cook and Farnam, they contain at various times ammonium nitrate, TNT, water, sodium borate, guar gum, urea, sodium nitrate, etc., in various proportions depending on blasting conditions and size of the hole.

The slurries have densities ranging from 1.4 to 1.7 and depending on the composition, can be used underground, on the surface in hard rock, and in wet holes. Drill patterns can allegedly be reduced by one-half. These slurry explosives can be obtained commercially or can be made at or near mine locations if properly licensed.

It was learned some time ago that a different so-called "slurry" was being packaged and tested in cans on the Mesabi Range. It involved Stengel process nitrate and a liquid, and it is thought through disclosure of British Patent 824,533—1958, that it consists essentially of ammonium nitrate, a nitro-paraffin and an organic amine.[6] The proportion of the three ingredients is such that the oxygen balance of the total mixture ranges from minus 15 percent to plus 15 percent. It is understood that this product is still in the development stage as far as practical usage is concerned.

Mixer-Placer Unit Developed By Swedes

The Swedes have also been active in work involving the mixing and loading of ammonium nitrate-fuel oil blasting agents. Recent publications describe development of a mixer-placer unit that mixes ammonium nitrate with fuel oil in a chamber.[7,8] When mixed properly the chamber

Placement of an ammonium nitrate-fuel oil mixture in blast holes from specially fabricated truck on the Mesabi Range

becomes a cylinder that is acted on by a piston of compressed air. The air virtually squeezes the ammonium nitrate-fuel oil mixture out of the unit through a loading pipe into the blast hole.

The ammonium nitrate used is reported to be a fine grained crystal, about the consistency of granular sugar and in this respect markedly differs from the product produced in the United States. In addition, it is given a special surface active organic treatment to prevent caking. Holes shot range from 1.1 to 1.9 in. in diameter and can be loaded at any inclination.

Wet holes are sometimes lined with a plastic tube which is placed over the loading pipe.

Field-mixed ammonium nitrate-fuel oil mixtures, along with the innovations that have developed in the use and handling of these mixtures, have enabled many mines to greatly reduce their operating cost without relaxing prudent safety measures in any way.

During the past few years when the mining economy has been depressed, the economies realized from the use of these field-mixed blasting agents has enabled many companies to continue to operate marginal properties. Although present practices in the use of ammonium nitrate-fuel oil mixtures have reduced blasting costs, let us not become so complacent as to think we cannot improve on existing practices. As the saying goes—"The world's your pretzel, bend it as you see fit."

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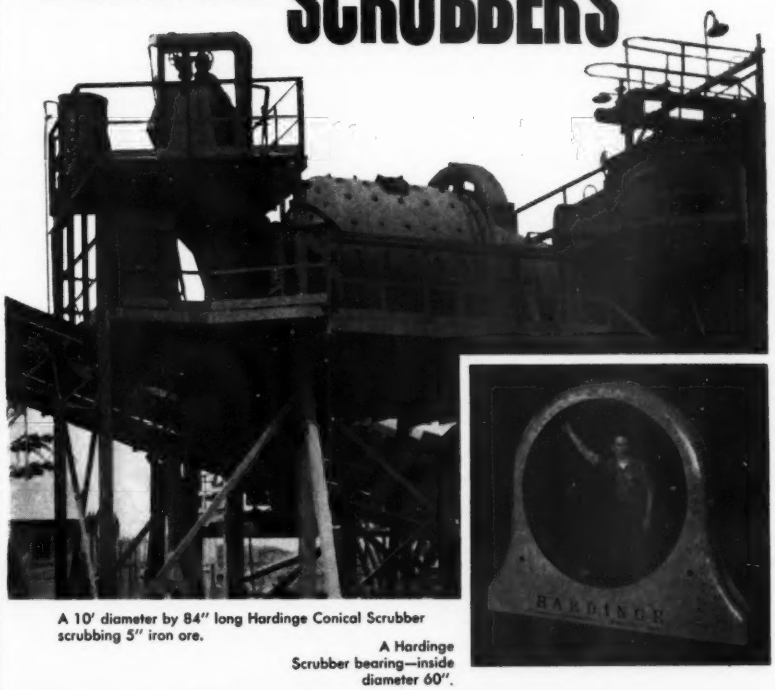

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FINE COAL CLEANING WITH TABLES

By

A. E. COPELAND, Assistant Chief Engineer

G. N. HAYNES, Superintendent of Preparation Plants

and C. W. PORTERFIELD, Director of Research-Testing and Sales Liaison

Pocahontas Fuel Co. Division
Consolidation Coal Co.

A resume of the Pocahontas field's experience with tables in cleaning raw coal

TABLES have been used by the coal industry for more than 40 years and many papers have been written concerning their history, theory of operation and actual performance. This report will pick up the history of the table as it applies to the Pocahontas field and discuss its operation in cleaning Pocahontas fine coal.

Prior to 1949, the year tables were first installed in the Pocahontas field, most mines had employed hand loading and, as a result, the low ash of the raw fines generally was satisfactory for the markets. However, with the adoption of full seam mechanical mining, the ash content of the fines increased significantly, and in addition, the raw fines became a greater percentage of the raw ROM. Today, about 65 percent of the raw ROM is 3/8 in. by 0 with an ash content which requires effective fine coal cleaning.

Table I shows the number of tables sold by Deister Concentrator Co. in the Pocahontas field in each of the years since 1949 and includes the number of double-deck units sold since their introduction in 1957.

Table I. Tables installed in the Pocahontas field

Single-Deck Table

Year	*Number*
1949	20
1953	24
1954	24
1955	12
1956	12
1957	64
Total Single-Deck	156

Double-Deck Table

Year	*Number*
1957	22
1958	20
1959	9
1960	16*
Total Double-Deck	67

**Ordered Thru February, 1960*

Figure 1 shows graphically the estimated tonnage washed on tables in the Pocahontas field. The authors estimate that in 1960 more than 55 percent of all slack in this field will be cleaned on tables.

Pocahontas Fuel Co. first installed tables in 1954 when fine coal plants using wet cleaning were added at its Bishop and Amonate preparation plants. Tables have now been added at all of the company's preparation plants and since 1957 all new tables have been the double-deck type. To date, the company has installed a total of 48 single-deck and 40 double-deck tables, but has not had an opportunity to install tables of both types in one plant.

Several of the double-deck tables are high capacity refuse discharge tables (HCRD) being used for special applications where the refuse percentage is higher than normal.

Performance—High-Ash Fines Pose Problem

Table capacity is determined principally by the following:

1. Washability of the raw coal.
2. Ash requirements in the clean product.
3. Amount of refuse in raw feed.
4. Size and ash consist of the raw feed.

In general the capacity of tables is

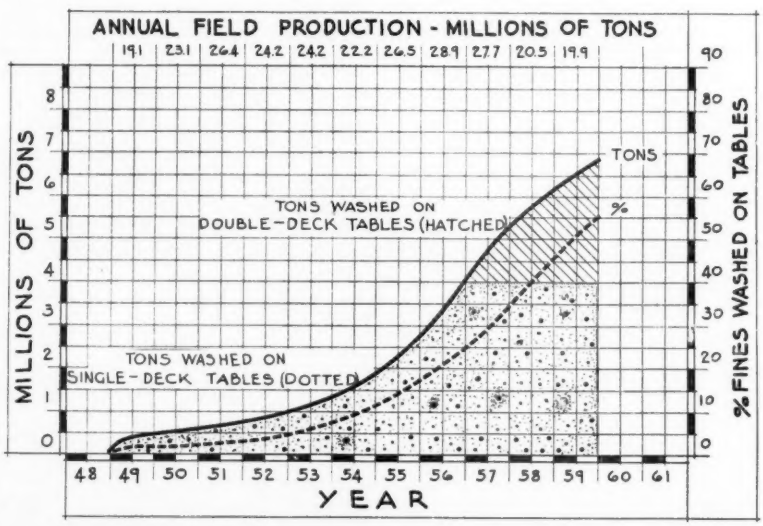
ANNUAL FIELD PRODUCTION - MILLIONS OF TONS
19.1 23.1 26.4 24.2 24.2 22.2 26.5 28.9 27.7 20.5 19.9
MILLIONS OF TONS
% FINES WASHED ON TABLES
TONS
%
TONS WASHED ON DOUBLE-DECK TABLES (HATCHED)
TONS WASHED ON SINGLE-DECK TABLES (DOTTED)
YEAR
48 49 50 51 52 53 54 55 56 57 58 59 60 61

Fig. 1. Estimated tonnage of Pocahontas coal washed on wet tables. More than 55 percent of all slack in this field will probably be cleaned on tables in 1960

decreased by lower ash requirements in the clean coal, by adverse washability of the raw coal, by an increase in the percentage of refuse, and by increased fines in the raw feed.

In the Pocahontas field, the washability of the raw coal is normally favorable and the percentage of rejects is not excessive. However, these are counterbalanced by stringent ash requirements in the clean slack and by the fact that the raw feed contains a large percentage of fines which are high in ash.

Deister Concentrator Co. normally recommends a feed of ten tph per deck. This is a conservative figure for the Pocahontas field, 12 to 15 tph being more representative of the feed rate in this field.

Table II shows a typical size consist and washability of raw 3/8 by 0-in. slack fed to tables at one plant in the Pocahontas field. You will note that the composite washability is good. Comparison of the 1.60 sp gr float product for the various size fractions shows that the 16 by 30-mesh fraction has the lowest ash and the highest recovery. The ash content increases and recovery decreases in the sizes coarser and finer than 16 by 30 mesh.

It should also be noted that the 100 by 200-mesh fraction constitutes about five percent of the raw feed and the 200 mesh by 0 constitutes almost six percent of the raw feed. The composite washability has been calculated for raw 3/8-in. slack with and without cleaning the 100 mesh by 0 fraction. These figures show that the uncleaned 100 mesh by 0 adds approximately one-half percent to the ash of the clean product. This is a situation encountered throughout the Pocahontas field, and explains the increasing interest in froth flotation. Pocahontas Fuel first installed froth flotation in 1956 and now has flotation systems in five of its largest plants.

Figure 2 shows graphically the composite washability of table II.

In the Pocahontas field the size usually tabled is 3/8 in. by 0. However, in some cases the 3/8 by 1/4 in. or 3/8 by 3/16-in. fraction is washed in a dense media vessel so that it can be cleaned at a specific gravity lower than can be obtained on tables.

There are no installations tabling a classified feed in the Pocahontas field. However, installations have been completed where the raw feed is deslimed hydraulically ahead of the tables by desiltors or by large cyclones. Dedusting ahead of tables is also being used at several plants.

Another method used in some plants to obtain a lower ash in the clean coal is to reject a portion of the coal from the clean coal side near the corner. This material can be sold in the steam market by itself or can be combined with a middlings product from the refuse side of the table.

In a number of plants, air tables are used as the primary fine coal cleaner, and Deister tables have been added to clean the rejects from the air tables. This method of operation reduces the ash in the clean slack without creating a moisture problem and also improves realization. This is particularly advantageous for older properties whose life expectancy is too limited to justify the capital expenditure required for complete wet cleaning and thermal drying facilities.

In cases where the percentage of refuse is excessive, high capacity refuse discharge tables can be used. The HCRD table has an additional eight ft of refuse launder around the back of the table which allows the refuse to move off the table much more quickly. This permits a better separation to be made because the refuse is prevented from piling up against the backboard of the table. In addition to the greater initial cost,

Table II. Size consist and washability of the raw feed to tables at one plant in the Pocahontas field

Screen Size, in rd & mesh	*Weight %*	*Ash %*	*Cumulative*	
			Weight %	*Ash %*
3/8 × 3/16	18.2	11.19	100.0	8.01
3/16 × 8	14.3	7.76	81.8	7.30
8 × 16	19.4	7.11	67.5	7.20
16 × 30	16.6	6.24	48.1	7.24
30 × 50	12.5	6.43	31.5	7.77
50 × 100	8.5	7.03	19.0	8.65
100 × 200	4.7	8.26	10.5	9.96
200 × 0	5.8	11.34	5.8	11.34
	100.0	8.01		

Washabilities of various size fractions

A. *Washability Of Raw 3/8 x 3/16-in.*

Sink	*Float*	*Wt. %*	*Ash %*	*Cumulative*			
				Float		*Sink*	
				Wt. %	*Ash %*	*Wt. %*	*Ash %*
	1.40	81.9	3.38	81.9	3.38	100.0	11.19
1.40	1.50	5.4	15.68	87.3	4.14	18.1	46.54
1.50	1.60	2.9	24.89	90.2	4.81	12.7	59.66
1.60		9.8	69.95	100.0	11.19	9.8	69.95
		100.0					

B. *Washability Of Raw 3/16 x 8M*

	1.40	87.9	3.01	87.9	3.01	100.0	7.76
1.40	1.50	4.5	15.14	92.4	3.60	12.1	42.28
1.50	1.60	1.8	24.62	94.2	4.00	7.6	58.34
1.60		5.8	68.81	100.0	7.76	5.8	68.81
		100.0					

C. *Washability Of Raw 8 x 16M*

	1.40	89.3	2.62	89.3	2.62	100.0	7.11
1.40	1.50	3.6	14.97	92.9	3.10	10.7	44.54
1.50	1.60	1.6	24.69	94.5	3.47	7.1	59.33
1.60		5.5	69.67	100.0	7.11	5.5	69.67
		100.0					

D. *Washability Of Raw 16 x 30M*

	1.40	90.2	2.39	90.2	2.39	100.0	6.24
1.40	1.50	3.7	14.48	93.9	2.87	9.8	41.67
1.50	1.60	1.1	23.75	95.0	3.11	6.1	58.16
1.60		5.0	65.73	100.0	6.24	5.0	65.73
		100.0					

E. *Washability Of Raw 30 x 50M*

	1.40	90.0	2.46	90.0	2.46	100.0	6.43
1.40	1.50	3.6	14.67	93.6	2.93	10.0	42.20
1.50	1.60	0.9	23.61	94.5	3.13	6.4	57.68
1.60		5.5	63.26	100.0	6.43	5.5	63.26
		100.0					

Table III. Table zone samples from a preparation plant in the Pocahontas field

Zone	TPH	Wt. %	Cum. Wt. %	3/8" x 3/16"		3/16" x 8M		8 x 16M		16 x 30M		30 x 50M		50 x 100M		100 x 200M		200 x 0M		Calc.		Zone
				Wt. %	Ash %	Wt. %	Ash %	Wt. %	Ash %	Wt. %	Ash %	Wt. %	Ash %	Wt. %	Ash %	Wt. %	Ash %	Wt. %	Ash %	Comp. Ash %	Cum. Ash %	
1	2.65	17.7	17.7	11.4	3.48	8.2	3.20	12.3	3.11	14.2	3.45	17.2	4.32	15.9	5.92	8.6	7.53	12.2	12.33	5.37	5.37	1
2	3.02	20.2	37.9	13.5	3.90	9.9	3.27	12.2	3.01	13.0	3.24	14.9	4.07	14.8	5.41	9.6	7.82	12.1	12.58	5.32	5.34	2
3	2.18	14.6	52.5	10.2	3.62	10.7	3.22	15.4	2.74	16.3	3.35	17.2	4.04	15.1	6.00	4.7	7.48	10.4	12.44	4.93	5.23	3
4	1.63	10.9	63.4	19.4	3.12	10.0	3.01	11.5	2.99	12.3	3.18	14.2	3.89	14.5	5.59	8.1	8.26	10.0	12.65	4.94	5.18	4
5	1.13	7.6	71.0	27.2	3.88	13.9	2.95	8.7	2.94	7.6	3.11	10.3	3.58	13.8	5.12	6.1	6.65	12.4	12.47	4.98	5.16	5
6	0.89	6.0	77.0	22.4	5.50	24.6	3.40	13.7	2.76	6.1	2.81	7.4	3.43	9.4	4.22	5.7	5.82	10.7	11.14	4.79	5.13	6
7	0.79	5.3	83.3	13.8	6.96	25.4	4.21	23.5	2.88	6.8	2.69	6.8	3.46	9.6	4.47	4.8	5.75	9.3	11.18	4.87	5.11	7
8	0.58	3.9	87.2	8.3	6.15	18.6	4.84	31.6	3.15	14.3	2.67	8.6	2.97	7.3	3.78	4.5	5.68	6.8	12.92	4.45	5.08	8
9	0.34	2.3	89.5	6.5	4.71	12.3	4.88	30.5	3.33	20.7	2.85	12.8	3.25	8.4	4.05	4.0	7.67	4.8	15.82	4.33	5.06	9
10	0.35	2.3	91.8	4.7	6.48	9.9	6.97	29.9	4.14	26.8	3.13	16.5	3.12	7.4	4.49	2.3	8.27	2.5	18.50	4.57	5.05	10
11	0.23	1.5	93.3	5.0	7.55	7.3	7.71	25.5	4.05	31.4	2.80	19.5	3.32	7.1	4.42	1.9	9.32	2.3	19.75	4.44	5.04	11
12	0.19	1.3	94.6	5.2	12.59	5.7	12.44	25.3	5.64	36.8	3.21	18.5	3.43	5.9	4.84	1.4	12.84	1.2	22.09	5.34	5.04	12
13	0.18	1.2	94.8	6.3	13.91	7.0	13.90	20.0	8.44	37.5	4.02	23.1	3.96	2.6	6.48	1.7	21.41	1.8	42.00	6.48	5.07	13
14	0.11	0.7	95.5	12.1	18.59	10.3	20.36	17.3	15.00	30.3	7.26	20.7	7.18	5.4	16.50	2.5	32.28	1.4	54.68	13.59	5.13	14
15	0.05	0.4	95.9	27.2	24.46	13.7	26.00	19.7	19.75	21.4	13.26	10.5	15.37	3.4	34.45	3.1	60.60	1.0	44.30	22.05	5.21	15
16	0.05	0.4	96.3	39.4	27.17	14.8	30.67	17.4	24.94	15.2	19.70	6.7	23.65	3.1	43.65	2.7	62.27	0.7	32.59	27.43	5.30	16
17	0.07	0.5	96.8	42.7	36.48	17.2	36.88	18.3	30.62	12.5	25.50	5.0	29.92	2.3	47.98	1.5	61.55	0.5	36.78	34.42	5.45	17
18	0.13	0.9	97.7	32.7	55.88	18.4	53.16	22.4	46.50	15.0	41.36	6.5	45.67	3.3	60.21	1.2	65.85	0.5	40.77	50.62	5.86	18
19	0.27	1.8	99.6	31.2	85.59	13.2	82.09	18.4	76.59	15.1	71.43	11.0	71.03	8.8	79.99	1.8	71.29	0.5	51.25	78.81	7.18	19
20	0.08	0.5	100.0	24.6	90.20	16.5	88.96	24.5	87.60	18.1	85.30	9.7	82.70	5.7	86.56	0.7	69.84	0.2	51.26	87.32	7.58	20
	14.92	100.0		14.8	9.97	12.2	7.04	15.5	6.46	14.1	5.72	14.1	5.47	12.9	6.82	6.6	8.33	9.8	12.64	7.58		
1–16	14.37	96.3	96.3	13.64	4.73	11.67	4.06	14.71	3.50	13.57	3.43	13.73	4.04	12.64	5.56	6.52	7.82	9.81	12.58	5.30	5.30	1–16
17–20	0.55	3.7	100.0	1.20	69.94	0.57	67.90	0.75	64.64	0.56	61.29	0.33	65.14	0.23	76.62	0.05	68.76	0.02	46.35	67.09	7.58	17–20
	14.92	100.0		14.84	9.97	12.24	7.04	15.46	6.46	14.13	5.72	14.06	5.47	12.87	6.82	6.57	8.33	9.83	12.64	7.58		
1–13	14.16	94.8	94.8	13.29	4.21	11.48	3.72	14.44	3.22	13.21	3.23	13.52	3.93	12.58	5.46	6.48	7.51	9.80	12.52	5.07	5.07	1–13
14–16	0.21	1.5	96.3	0.35	24.26	0.19	25.93	0.27	18.96	0.36	10.80	0.21	10.86	0.06	25.60	0.04	57.57	0.01	48.45	18.90	5.30	14–16
17–20	0.55	3.7	100.0	1.20	69.94	0.57	67.90	0.75	64.64	0.56	61.29	0.33	65.14	0.23	76.62	0.05	68.76	0.02	46.35	67.09	7.58	17–20
	14.92	100.0		14.84	9.97	12.24	7.04	15.46	6.46	14.13	5.72	14.06	5.47	12.87	6.82	6.57	8.33	9.83	12.64	7.58		

HCRD tables cost more to install than standard tables, because of the extra labor and material for launders and piping.

Table III shows the analyses of samples taken from the various zones of one table at a preparation plant in the Pocahontas field. Figure 3 shows the locations of the various zones starting with the feed end of the clean coal side, progressing down the clean coal side and ending on the refuse side.

The tons per hour being discharged, the size consist and ash of each size for each zone are given in table III. These results show that raw coal was being fed to the table at the rate of 14.92 tph.

As is normally the case in the Pocahontas field, the ash content of the composite zone samples decreased through the first 11 zones. This is the result of several factors.

First, the coarse sizes, which have a more adverse washability, tend to be cleaned on the first few zones. Second, a large percentage of the middle sizes which have the most favorable washability come off further along on the clean coal side of the table. Third, the extreme fines tend to be washed over without any cleaning in the first few zones because of the rush of feed water.

Table III also indicates the relative effectiveness with which a table cleans the various size fractions. Although washability tests were not made for each size in each zone, it can be seen that the cleaning efficiency drops off at about 50 mesh. The ash content of the 50 by 100-mesh fraction is reduced from 6.82 percent to 5.56 percent in the first 16 zones—a reduction of 1.26 percent ash. The 100 by 200-mesh fraction shows a reduction of only 8.33 – 7.51 = 0.82 percent ash and the ash reduction in the 200 mesh by 0 is negligible: 12.64 – 12.58 = 0.06 percent.

The effect of making a middlings product is also shown. If zones 14–16 are combined as a middlings product at 18.90 percent ash, 0.21 tph is removed from the clean coal and the ash content of the clean coal is reduced from 5.30 percent to 5.07 percent.

Single-Deck Versus Double-Deck Tables

Many of the advantages of the double-deck table are obvious and apply in all coal fields.

More economical to install. Although the price of a complete single-deck table is about one-third of

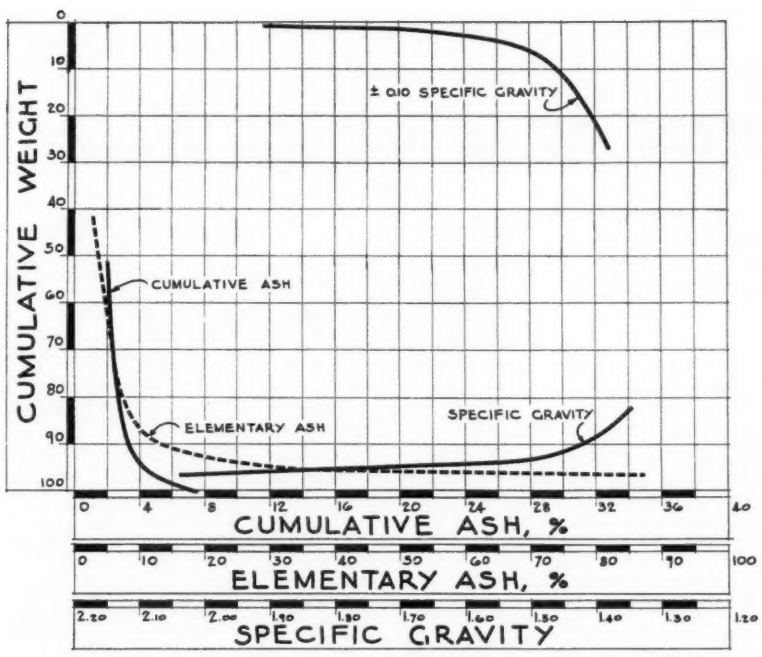

Fig. 2. Based on the data given in table II, the washability of Pocahontas 3/8-in. by 0 slack is pictured graphically

that for a double-deck table, double-deck units can be installed more economically for the following reasons:

1. A double-deck table can be installed in the same floor space required for a single-deck unit. Therefore, only half as much floor space is required for the same number of decks.

2. The double-deck table is suspended on wire ropes and as a result imparts very little vibration to the supporting structure and floor system. This means that a lighter structure can be used compared with the heavy structure required to withstand the vibration of floor mounted single-deck tables.

3. Piping, wiring, etc., substantially less for the double-deck tables.

4. Labor cost of installation of one double-deck table is considerably less than for installation of two single-deck tables.

Ease of adjustment. End elevation on the double-deck table can be changed easily even while the unit is in operation by means of a turn buckle which is located on the end of one of the supporting cables. This feature would be particularly important at a central cleaning plant where several coals with different washability characteristics were being cleaned on alternative shifts.

Side tilt can be adjusted easily on either type table.

Efficiency of cleaning. Both type tables do a good cleaning job in the Pocahontas field. However, it cannot be stated definitely that the double-deck table does a better cleaning job than the single-deck under identical conditions.

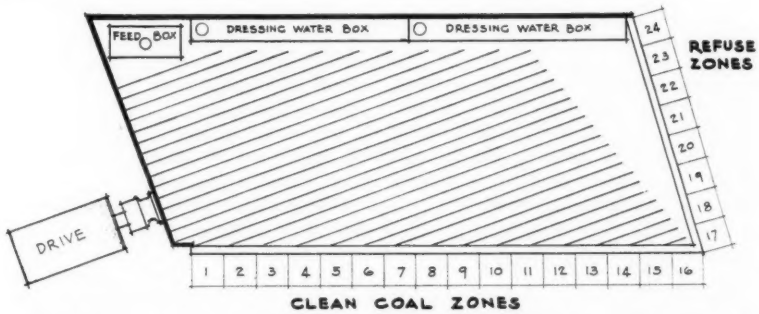

Fig. 3. Location of various table zones starting with the feed end of the clean coal side, progressing down the clean coal side and ending on the refuse side. See table III for analyses of samples taken from the various zones of one table at a plant in the Pocahontas field

Maintenance. Maintenance costs are quite low on either type table. However, since the principle item of maintenance is the drive mechanism, the double-deck table will undoubtedly have lower maintenance costs since only one drive mechanism is required for two decks.

Several minor weaknesses have been encountered in the double-deck table but corrections have been made by the manufacturer. The swivel connector between the drive and the table and the yoke connecting the two decks have been the two most common weak points. Redesigned replacement parts appear to have corrected the difficulties.

Housekeeping. Because the double-deck unit is suspended from overhead supports, the floor space under the table is open, which permits and encourages better housekeeping.

Cost of operation. The cost of operation of either type table is quite low. However, the double-deck table, having only one 3-hp motor, one drive mechanism and one oil system, should have one-half the operating cost.

Cost of Auxiliary Equipment

One or two Deister tables have been added at a number of the smaller preparation plants in the Pocahontas field to back up other cleaning equipment such as air tables. In an installation of this kind, the Deister table cost is the major portion of the total cost of the installation. However, when a complete Deister plant is built, the cost of the tables is small compared to the cost of the auxiliary equipment required to dewater and dry the clean coal and to close the water circuit.

Table IV. Breakdown of costs for a table plant in the Pocahontas field

Item	*Percent*
1. Engineering	9
2. Structure and foundations	23
3. Feed preparation	6
4. Double deck tables	5
5. Conveyors, pumps, and piping	5
6. Mechanical dewatering	6
7. Thermal drying	23
8. Water clarification	12
9. Wiring and controls	9
10. Heating system	2
	100

Table IV shows a typical breakdown of the cost of a complete double-deck table plant in the Pocahontas field.

From these figures you will note that the cost of the double-deck tables is only five percent of the total cost of the complete plant.

Mineral resources on the ocean floor

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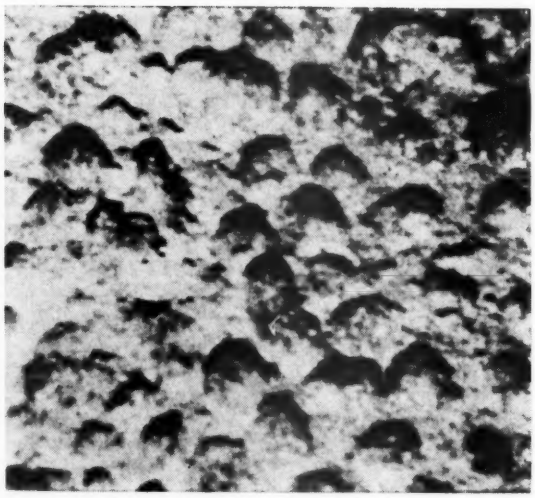

Fig. 1. With deep-sea cameras information can be obtained as to the local concentration of the sea-floor nodules. Photographed in 12,400 ft of water about 220 miles southwest of the southern tip of Baja California, the sea-floor shows a concentration of manganese nodules of 4.9 lb per sq ft. Average diameter of the nodules is about 1.3 in.

In the oceans lie vast undeveloped resources of many of the materials needed by industry

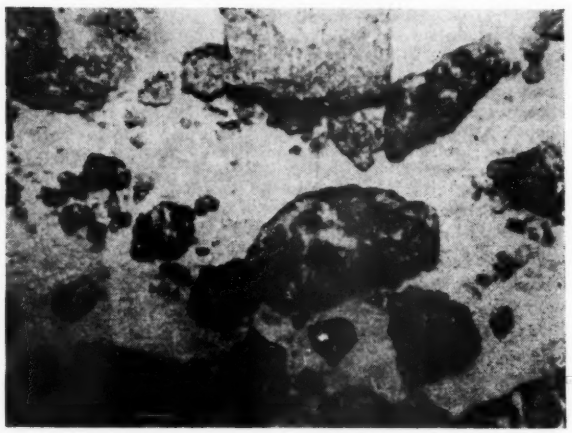

Fig. 2. The surface concentration of these manganese nodules photographed in 14,100 ft of water about 1000 miles west of Baja California, is 8.8 lb per sq ft. The largest, slab-like nodule is about nine in. in diameter

THE sediments in the ocean can be placed in two broad classifications, terrigenous and pelagic. Terrigenous sediments are found on the continental slope and around the margins of the deep-sea basins. These sediments generally contain some coarse-grained materials and have a wide range in depth, color, composition, and texture. Terrigenous sediments in certain areas consist almost entirely of the shells and skeletons of benthonic animals and, consequently, could serve as a source of limestone for the cement industry. Dow Chemical Co. presently dredges calcareous shells from the Gulf Coast area to use in the precipitation of magnesium from seawater.

Pelagic sediments are found in deep water far from the shores of the continents. These sediments may be either inorganic or organic in origin. They are very fine-grained, usually light reddish brown, and generally contain skeletal remains of plankton organisms. Pelagic sediments which contain less than 30 percent organic remains are called red clay, those which contain more than about 30 percent organic remains are known as oozes. The oozes are divided into two major groups, the calcareous and the siliceous. Commonly found with the pelagic sediments are whale earbones, iron-nickel spherules, shark teeth, and manganese nodules.

Manganese Nodules

The first published description of manganese nodules was that by Sir John Murray in the Challenger Reports which were printed in 1891.[1] These small, brown-black, concretions were found widely distributed at the surface of the sea floor in the pelagic areas of the three major oceans of the world.

Agassiz conducted extensive dredging in the central and southeast Pacific Ocean around the turn of the century. He came to the conclusion that here was an area larger than continental United States literally covered by manganese nodules,[2] for at almost every station dredged in the eastern Pacific Ocean manganese nodules were recovered. Last summer in dredging between San Diego and Hawaii we had the same experience.

Fig. 3. A concentration of manganese nodules of about five lb per sq ft was found about 250 miles south of Tahiti in 15,400 ft of water

Until development of the deep-sea camera, there was no way of knowing with any accuracy what the concentration of manganese nodules might be. About 12 years ago, the first really successful deep-sea photograph showing the sea floor was made. Since that time a number of deep-sea cameras have been developed and data now being gathered suggests that the sea floor in the eastern Pacific is indeed covered with deposits of manganese nodules,[3,4] Figures 1, 2, and 3, show deposits in the Pacific, while figure 4 shows a deposit of the nodules in the Atlantic Ocean.

Description of the Nodules

Manganese dioxide is distributed in the deep-sea sediments as grains, nodules, slabs, coatings on rocks, impregnations of porous material, and in other less important forms. The shape is highly variable, but is most often potato-like. Slab-like nodules sometimes are only manganese-coated chunks of pumice which have floated to their present position from volcanic eruptions. Although the nodules generally range from one to nine in. in diameter, in deposits of relatively pure manganite, they are usually very uniform in size.

The largest nodule ever brought to the surface was a 300 lb mass, which was entangled in a telegraph cable being raised for repair about 600 miles southwest of Dakar, Africa. It was tossed back into the ocean after it had been sampled and sketched. Another large nodule was found in the Pacific when a 125-lb mass was recovered in a tangle of core-barrel wire, an excess of which had been let out by mistake. This nodule, which was found in an area about 1500 miles north of Hawaii, is now on display at Scripps Institution of Oceanography.

The opening of the dredge bucket presently used is too small to permit nodules larger than about one ft in diameter from entering. As far as is known, there is no reason why the nodules could not grow to very large sizes, and, as additional photographs of the sea floor are taken, nodules much larger than those that can be recovered with the oceanographic dredge will probably be found.

In cross-section, the nodules display thin, concentric, onion-like growth layers. They commonly have a nucleus of red clay, a basaltic fragment, pumice, a shark tooth, or a whale earbone. The nodules are light and very porous with specific gravities ranging from 3.1 to 2.0, but usually about 2.4. The color varies from black to brown depending on the iron content.

Mineralogy of the Nodules

Sea-floor manganese oxides are comparable to wad or bog manganese. In addition to manganese peroxides, the nodules generally contain limonite, alumina, silica, and considerable amounts of copper, cobalt, and nickel.

Manganese is added to seawater by streams, submarine volcanic eruptions, sea-floor springs, and decomposition of manganese-rich sea-floor eruptives. Local reducing atmospheres cause it to go into solution, but as the manganese ion migrates into the general oxidizing atmosphere of the ocean, it changes valence and precipitates as a colloidal, hydrated, manganese dioxide.[5] Iron acts much the same.

In filtering down through the seawater, the colloids of manganese and iron oxides apparently scavenge nickel, copper, cobalt, zinc, molybdenum, vanadium, lead, and other metals.[6] These colloidal particles carry an electric charge and are attracted to hard-surfaced objects, which are better conductors of electricity than the unconsolidated clays or oozes, thus forming nodules instead of a uniform layer of iron-manganese-rich sediment.

Silica and alumina are often included in the nodules as physically entrapped clay particles. Because of the intimate mixture of the manganese, iron, nickel, cobalt, and copper minerals, there is little hope of separating these metals by any physical process, but the nodules can be up-

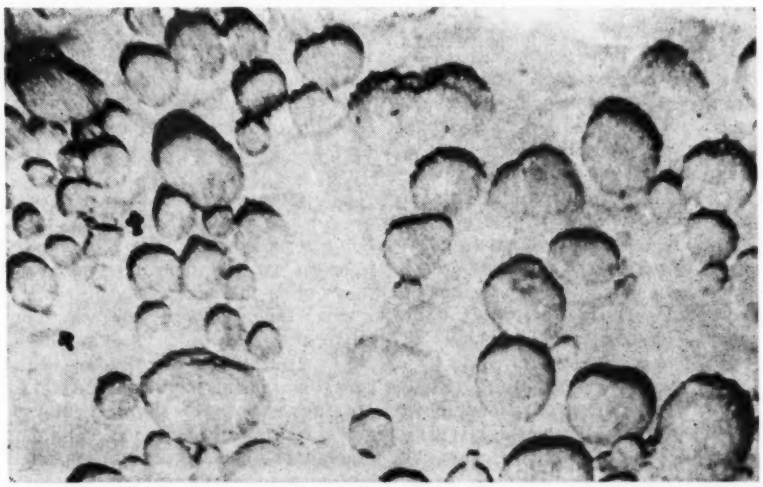

Fig. 4. A manganese concentration in the Atlantic, 300 miles southeast of Bermuda, contains about ten lb of manganese nodules per sq ft of ocean floor. A second layer of nodules, partly covered by sediment, is noticeable

graded by a factor of as much as two by a crushing, washing, and drying process which removes much of the silica, alumina and water.

Effect of Ocean Currents on Nodule Formation

Although there is no reason why nodule deposits could not occur in high concentrations in depth on the ocean floor, there is little evidence to suggest that this might be the case. At present there is no method to take a large diameter core of ocean sediments at great water depths. Small nodules are often found distributed throughout the length of small diameter cores taken of pelagic sediments, however, very few cores have been examined for manganese nodules, and no definite conclusions can be drawn.

A very low sedimentation rate of the clays and oozes seems to be necessary for formation of manganese nodules. Small, but noticeable, ocean-floor currents, that exist at many places in which the nodules are forming, sweep away extraneous fine sediment allowing the nodules to attract only the charged particles of manganese and iron oxides. Should the sedimentation rate exceed the rate of growth of the nodules, the nodules will be buried and cease to form. If the nodules occur in depth at any location, therefore, they will probably be found highly concentrated at discrete horizons.

Composition of the Nodules

The maximum, minimum, and average assay of 30 samples of manganese nodules from all of the world's oceans are shown below:

Composition of Manganese Nodules

Material	*Weight Percentages**		
	Maximum	*Minimum*	*Average*
MnO_2	90.0	11.4	31.7
Fe_2O_3	44.1	0.8	21.7
SiO_2	42.3	2.8	19.4
Water	29.7	8.7	13.7
Al_2O_3	12.8	0.3	4.6
$CaCO_3$	10.2	0.9	3.5
$CaSO_4$	1.3	0.3	0.7
$Ca_3(PO_4)_2$	7.2	0.0	0.5
$MgCO_3$	4.9	0.1	2.3
NiO, CoO, CuO, MoO, ZnO, PbO, V_2O_5, Rare Earths	6.1	0.1	2.0

* *Largely from Murray and Renard, 1891.*

Table I lists the manganese, iron, cobalt, nickel, and copper contents of 33 samples of manganese nodules from the eastern Pacific Ocean. Molybdenum, vanadium, lead and zinc are generally present in the nodules in amounts ranging from a few hundredths of a percent to a maximum of about 0.2 percent.

TABLE I

METALLIC COMPOSITION OF MANGANESE NODULES FROM THE EASTERN PACIFIC OCEAN

Sample No.	*Location of Sample*			*Weight Percentages* (Dry Weight Basis)*					*Station No.*
	Latitude o-'	*Longitude o-'*	*Depth (Feet)*	*Mn*	*Fe*	*Co*	*Ni*	*Cu*	
R1-1	29-57 N	120-42 W	13,170	20.6	15.5	0.16	0.95	0.64	Vitiaz 4217
R1-2	27-20 N	116-10 W	13,200	22.4	6.8	0.02	0.61	0.82	PAS 19121**
R1-3	22-18 N	107-48 W	9,840	27.5	2.6	0.06	0.11	0.04	UNK-RP
R1-4	6-58 N	81-44 W	3,480	18.9	22.8	0.46	0.26	0.06	AA 4676
R2-1	28-23 N	126-57 W	14,200	50.0	0.8	0.01	0.06	0.06	Alb 2
R2-2	7-48 S	94-06 W	13,400	43.6	4.4	0.03	1.25	0.75	AA 4711
R2-3	9-56 S	87-30 W	14,550	47.6	2.4	0.01	0.67	0.43	AA 4660
R2-4	8-30 S	85-36 W	16,400	49.2	1.0	0.00	0.11	0.15	AA 4658
R2-5	25-31 S	85-14 W	3,010	48.5	2.8	0.14	0.25	0.18	DWHD 72
R3-1	19-49 N	121-44 W	14,240	26.9	12.8	0.44	1.41	1.15	UNK-RR
R3-2	9-57 N	137-47 W	16,140	35.6	5.7	0.20	1.57	1.63	Alb 13
R3-3	10-26 N	126-43 W	14,080	28.0	10.2	0.27	1.48	1.63	DWBD 2
R3-4	41-49 S	102-01 W	13,740	30.4	12.9	0.15	1.24	0.87	DWHD 47
R3-5	15-23 S	136-18 W	14,650	25.2	10.0	0.11	1.49	1.53	DWHD 15
R3-6	8-08 S	104-11 W	12,500	28.0	16.6	0.01	1.08	0.99	AA 4721
R3-7	11-14 S	89-35 W	14,630	30.0	10.6	0.14	1.34	1.03	AA 4662
R3-8	14-29 S	81-24 W	16,270	28.6	9.5	0.07	1.59	1.14	AA 4676
R3-9	18-47 S	89-26 W	14,360	32.7	10.8	0.23	1.49	1.05	AA 4681
R3-10	21-36 S	94-56 W	13,210	19.0	13.0	0.22	1.47	0.86	AA 4685
R3-11	46-44 S	123-01 W	13,410	19.4	11.5	0.28	0.98	0.67	DWBD 7
R3-12	41-24 S	129-06 W	15,980	25.5	15.5	0.48	0.94	0.53	DWHD 54
R3-13	13-28 S	149-30 W	14,100	27.8	15.4	0.46	1.00	0.55	Chal 276
R4-1	18-55 S	146-32 W	14,640	18.3	20.0	0.62	0.24	0.22	Alb 173
R4-2	13-20 S	146-30 W	5,580	30.7	15.8	2.02	0.77	0.16	DWBD 4
R4-3	16-29 S	145-33 W	4,150	30.9	19.0	1.46	0.73	0.19	DWHD 16
R4-4	19-07 N	169-44 W	5,700	28.6	20.2	1.30	0.53	0.22	MP-25-F2
R4-5	17-04 N	177-15 W	6,500	16.8	15.4	0.54	0.55	0.28	MP-37A
R4-6	19-03 N	171-00 W	4,500	30.0	17.5	1.16	0.72	0.16	MP-26A3
R5-1	23-17 N	141-13 W	17,670	19.3	15.3	0.54	0.54	0.42	Naga-NH 10
R5-2	23-54 N	148-00 W	17,100	12.7	12.3	0.22	0.85	0.60	Naga-NH 15
R5-3	22-00 N	150-00 W	17,160	19.3	19.2	0.48	0.51	0.44	Naga-NH 16
R5-4	40-14 N	155-52 W	16,500	14.8	12.2	0.26	0.68	0.68	No. H-10
R5-5	40-20 N	135-47 W	15,000	20.7	13.5	0.26	0.88	0.55	Vitiaz 4191

* *As determined by the author by x-ray fluorescence methods.*
** *From Goldberg, 1954.*

Deposits in the Eastern Pacific Ocean

Most of the samples of nodules presently available that have been assayed for manganese, nickel, cobalt, and copper were taken from the eastern Pacific. On the basis of about 60 samples, which admittedly is not adequate sampling when dealing with half the area of the Pacific Ocean, but considering the uniform nature of pelagic sediments, probably is significant, it is possible to speculate on the existence of compositional regions of the nodules in the eastern Pacific Ocean. These regions are shown in figure 5.

REGION ONE. Composition of nodules in Region One seems to be highly variable due to physical inclusion of detrital material within their structure. The manganite phase of the nodules from certain localities, however, seems to be relatively free of cobalt, nickel, or copper, and a physical concentration process could likely be used to upgrade these nodules to a premium-grade metallurgical manganese dioxide.

Concentrates of nodules dredged from one location assayed almost 98 percent MnO_2 (private communication, E. D. Goldberg). Because this material is formed by the agglomeration of colloidal precipitates, it has a very large surface area, and it might serve as a battery-grade manganese dioxide.

The deposits found in this region are probably localized, rather than being spread over hundreds of square miles as are the deposits found further out in the ocean. Due to the irregular topography of the sea floor adjacent to the west coast of southern North America, limited areas with very low clastic sedimentation rates are found close to shore. In these areas, electrically charged colloidal precipitates can accrete unimpeded by terrigenous sediments.

Although there is evidence of the formation of manganese nodules in

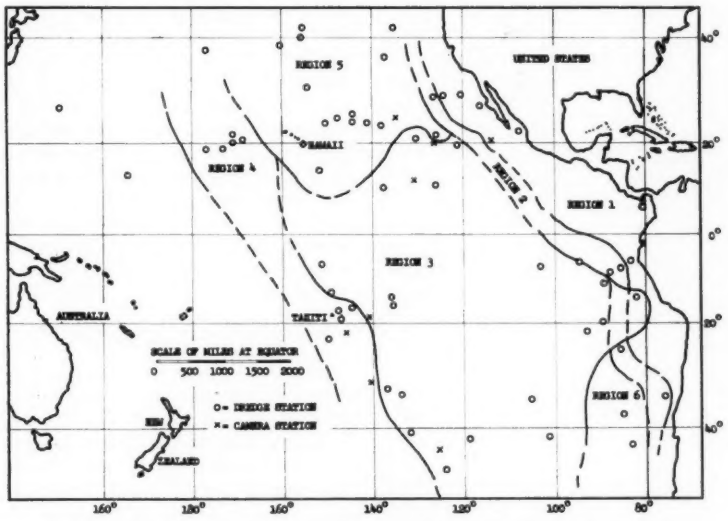

Fig. 5. Compositional regions of manganese nodules in the eastern Pacific Ocean

the areas close to continental shores of all oceans, high rates of clastic sedimentation tend to dilute these deposits so that the manganese content is rarely much greater than one or two percent.

REGION TWO. Following the outline of the coasts of North and South America is a belt of nodules which contains a relatively high percentage of manganese dioxide. Along North America, this belt seems to lie about 300 to 500 miles offshore, but along South America, it is more irregular and at one point it seems to be within 200 miles of the coast of Peru.

One sample of nodules from this belt assayed 50 percent manganese, 0.01 percent cobalt, 0.06 percent nickel, and 0.06 percent copper. Four other samples averaged 48.8 percent manganese, 0.04 percent cobalt, 0.18 percent nickel, and 0.2 percent copper. Another taken near the boundary of Regions Two and Three contained 43.6 percent manganese, 0.03 percent cobalt, 1.25 percent nickel, and 0.75 percent copper. All of these assays are expressed on a dry weight basis.

Region Two covers an area of about two million square miles, and at a surface concentration of one lb of nodules per square foot would contain about 26 billion tons of nodules. The two photographs taken in or near this belt showed surface concentrations of 4.9 and 7.0 lb per square foot, however, these photographs, obviously, cannot be considered representative of the whole belt.

REGION THREE. The central part of the southeastern Pacific Ocean seems to be an area of high-nickel, high-copper nodules. The best grade of material found thus far assayed 35.6 percent manganese, 0.2 percent cobalt, 1.6 percent nickel, and 1.6 percent copper. Thirteen samples from this area averaged 27.4 percent manganese, 0.2 percent cobalt, 1.3 percent nickel, and 1.1 percent copper.

Region Three covers about 14 million square miles and assuming an average surface concentration of one lb per square foot, which concentration, the author believes, would be economic to mine, a reserve of about 200 billion tons of nodules is indicated. Four photos taken in this area show concentrations of 8.2, 3.0, 3.7, and 7.0 lb per square foot.

REGION FOUR. Along the mid-Pacific rise, which includes the Society Islands in the South Pacific and lies just west of Hawaii in the northern latitudes, is an area of relatively high-cobalt nodules. Six samples of nodules from this area averaged 25.7 percent manganese, 1.2 percent cobalt, 0.6 percent nickel, and 0.2 percent copper. The best analysis showed 30.7 percent manganese, 2.0 percent cobalt, 0.8 percent nickel, and 0.2 percent copper.

A lack of samples between 150° W longitude and Australia makes placement of the western boundary of this area uncertain. These high-cobalt nodules seem to be localized on or near topographic highs in the pelagic areas so the western boundary of the mid-Pacific rise may be their western limit. The two surface concentration measurements made of nodule deposits in this area indicated about five lb per square foot in both cases. An advantage of this area from the mining standpoint is that much of it is less than 5000 ft in depth, whereas the general depth of the ocean in the other areas is about 14,000 ft.

The Northeastern Pacific Region

The northeastern Pacific seems to be an area of generally low-grade material with the best sample assaying 20.7 percent manganese, 0.3 percent cobalt, 0.8 percent nickel, and 0.6 percent copper. Five samples from Region Five averaged about 17.4 percent manganese, 13.5 percent iron, 0.4 percent cobalt, 0.7 percent nickel, and 0.5 percent copper. Also, in the area east of Hawaii, much of the bulk of many nodules consists of pumice which is merely coated with manganese dioxide.

Two samples of nodules from Region Six in the southeastern corner of the Pacific Ocean averaged 19 percent manganese and 27 percent iron. No copper, nickel, or cobalt assays were available.

No one is likely to invest in a deep-sea mining venture on the basis of this sparse sampling of the Pacific basins, but data from dredge haul samples and sea-bottom photographs do indicate that these areas are worth further exploration.

Although the manganese nodules are of little strategic value militarily, politically and economically they would be of major strategic value for the U. S. for they could serve as an alternate source of manganese, nickel, cobalt and copper if the necessity arose. And, if proven economic to mine and process, these deposits, because of their vast extent and availability to all, would tend to stabilize world prices for these metals.

Manganese Nodules in the Atlantic Ocean

Although manganese nodules are found at many locations in the Atlantic Ocean, they seem to contain less manganese, nickel, cobalt, and copper than those from the southeast Pacific.

The iron content of the Atlantic nodules is relatively higher than that of the Pacific nodules and generally is equal to or better than the manganese content. A typical analysis of Atlantic Ocean nodules is 18 percent manganese, 18 percent iron, 0.5 percent cobalt, 0.3 percent nickel, and 0.2 percent copper.

An interesting deposit of nodules in the Atlantic, however, is that on the Blake Plateau, an area of about 75,000 square miles off the coasts of the Carolinas and Florida that ranges

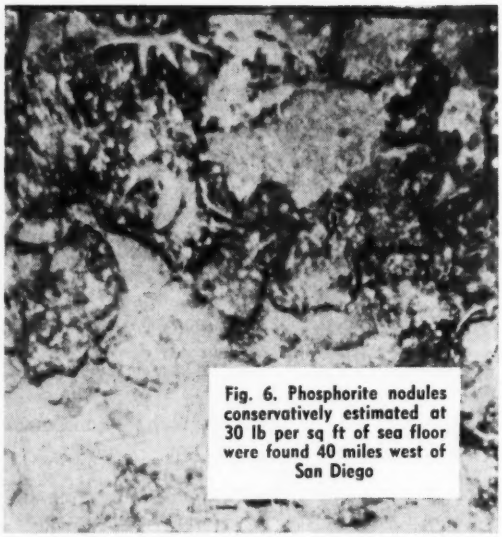

Fig. 6. Phosphorite nodules conservatively estimated at 30 lb per sq ft of sea floor were found 40 miles west of San Diego

in depth from 500 to 3000 ft. Although there is evidence of extensive deposits of nodules here, the three samples from this area available for analysis show the typical, low-grade assay of Atlantic Ocean nodules. The reason the nodules are forming on the Blake Plateau, in relatively shallow water and close to a continental shore, is that the Gulf Stream apparently sweeps it free of terrigenous sediments.

Other Pelagic Sediments Of Economic Interest

RED CLAY. Red clay is a form of pelagic sediment that covers some 40 million square miles of ocean floor. Its general composition is about 50 percent silica, 7 percent calcium carbonate, 20 percent alumina, 13 percent iron oxide, 3 percent magnesium carbonate, 6 percent water, with minor amounts of manganese, nickel, cobalt, copper, and vanadium oxides. Its composition is quite similar to that of the average of igneous rocks but with a ten-fold enrichment in manganese, nickel, cobalt, copper, lead, and molybdenum. Copper content of the red clays generally is about 0.2 percent. Alumina content of Atlantic Ocean red clays approaches 25 percent.

This material, because of its lack of solid overburden and its fine-grained and unconsolidated state, would probably be a much more attractive source of copper and alumina than a land deposit of similar grade. At an average sediment depth on the ocean floor of 100 meters, which is a very conservative estimate, the red clay contains about 10^{14} tons of alumina and about 10^{12} tons of copper.

DIATOMACEOUS OOZE. Stretching across the north and south sides of the Pacific are vast belts of predominately siliceous oozes. An area of about 11 million square miles of the sea floor is covered by this type of sediment, which is almost pure silica, and, like the red clay is very fine-grained and unconsolidated. It would serve for any of the purposes for which diatomaceous earth is now used. A disadvantage of these deposits is that they lie at latitudes of about 50 degrees north and south of the equator and consequently are relatively far removed from any markets.

NICKEL-IRON SPHERULES. A common constituent of the pelagic sediments are nickel-iron spherules. This material is thought to be of cosmic origin; the result of meteorites getting through the earth's atmosphere. It is magnetic and could be easily separated from the red clay or oozes in any hydraulic pumping operation. Although widespread, it does not occur in any known high concentrations and would probably only serve as a by-product from some other recovery operation.

GLOBIGERINA OOZE. About 50 percent, or some 50 million square miles, of the ocean floor is covered with a type of sediment termed globigerina ooze. This material assays as high as 95 percent calcium carbonate, but the average is very similar to that of ASTM Type I and II cement rocks, which account for about 95 percent of the cement rock market.

At a 100 meter average depth, there would be about 10^{14} tons of cement-grade globigerina ooze. This ooze is also very fine-grained and unconsolidated. Extensive deposits lie within a few hundred miles of most of the countries bordering the oceans and the material could serve as a cement "rock" for those countries lacking deposits of cement-grade limestone.

BARIUM SULPHATE CONCRETIONS. Barium sulphate concretions, assaying about 75 percent barium sulphate, have been dredged from just south of San Clemente Island, about 40 miles off the southern California coast, and from near Ceylon. They are apparently the result of the precipitation of barium from barium-rich solutions entering the ocean water through sea-floor springs that have their origin in the continental or island rocks. The concretions do not seem to be wide spread, but little is known about their occurrence, mode of formation, or concentration.

Animal Remains on the Sea-Floor

Shark teeth and whale earbones are very common objects on the deep-sea floor. Generally, when a fish dies, the calcareous-biogenous material is dissolved away before the remains can sink to the sea floor. Shark teeth and cetacean earbones, however, are composed primarily of tri-calcium phosphate.

The lower waters of the ocean are generally saturated in phosphate; consequently, when these objects reach the sea floor, they remain intact. Shark teeth grade to 34 percent P_2O_5 and are relatively low in fluorine. Although it is doubtful that these materials would serve as a source of phosphate, they could be recovered as a by-product from any deep-sea manganese nodule mining operation. The shark teeth are commonly found in great quantity with manganese nodules as in these non-sedimentational environments considerable deposits have a chance to collect without being buried by sediment.

Certain sea animals have the ability to extract elements from seawater and concentrate them in various parts of their bodies. Some of the tunicates can concentrate vanadium to over 50,000 times that of the concentration of vanadium in seawater. Oysters can effect a 200-fold concentration of copper from seawater.

Analyses performed by Arrhenius and his coworkers at Scripps have shown several percent of rare-earth elements, 0.6 to 1.5 percent of zinc, 0.1 to 0.5 percent of copper, 0.05 to 0.15 percent of tin, and 0.03 to 0.1 percent of lead in fish skeletal remains.[7] Concentrations of nickel and silver are found in fish debris, but so little data exist at present that their economic significance is unknown.

Phosphorite Nodules

Another material dredged at many locations, generally on the continental shelves, is phosphorite. It has been found off the east coast of Australia, off Japan, Spain, on the Agulhas Bank

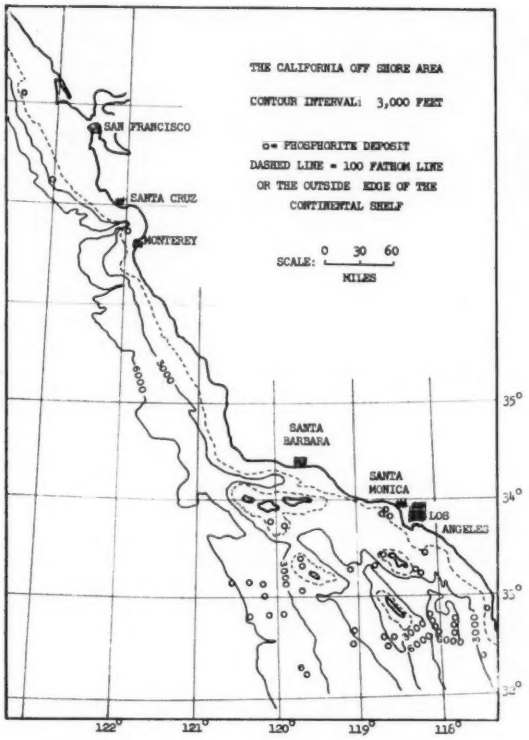

Fig. 7. Map of the California off-shore area shows locations where dredge hauls consisted almost entirely of phosphorite nodules. A favorable environment for the formation of phosphorite seems to be a nondetrital type of area where sea-floor currents are sufficient to sweep clastic sediments away allowing the colloidal precipitates to accrete unimpeded

off South Africa, along the Atlantic coast of the U. S., and the west coasts of North and South America.

Generally, this material is found in shallow water, sometimes less than 100 ft, but it is also found in water over 10,000 ft in depth. The P_2O_5 content is usually around 20 percent but often ranges up to 30 percent. The lower grades are usually the result of the physical entrapment of siliceous material within a high-grade phosphate matrix.

Extensive phosphate deposits were discovered off the coast of southern California in 1937 by Shepard of Scripps,[8] and since then phosphate rock has been dredged in about 125 locations from north of San Francisco to just south of San Diego.

This sea-floor phosphorite occurs as nodules which vary in shape from flat slabs to irregular masses. Smoothly rounded protuberances on the sides of these nodules indicate that they are the result of accretion rather than abrasion. The nodules are firm, dense, with a specific gravity of about 2.62, and hardness of about 5.

Nodules from a particular area have a group resemblance especially in color, and range in size from oolites to chunks over a yard in diameter. Figure 6 shows the phosphorite at a depth of about 600 ft on the sea floor about forty miles west of San Diego while figure 7 shows some of the locations where phosphorite has been dredged in large quantities in the California offshore area.

Collophane, composed of isotropic carbonate fluorapatite, is the principal mineral in which the phosphate is present in these nodules. Chemical analyses of samples from five different deposits off southern California show the nodules in this area to be surprisingly uniform in composition. The P_2O_5 content is about 29 percent, while the insol and fluorine content are about three percent each. The R_2O_3 content is generally less than a percent and water content is about ten percent.[9]

Economics of Mining Deep-sea Phosphorite

California has no commercial-grade deposits of phosphorite but imports over 100,000 tons of P_2O_5 annually. The cost of the imported phosphate rock at California points is as high as $15 per ton, about half of the total cost being freight. Because of the slight transportation costs involved in marketing the off-shore phosphorite, these deposits may be commercial to mine for the California market.

A report on the economics of mining deep-sea phosphorite[10] indicated that with a capital investment of $3.5 million a drag dredge system, patterned after the present method of deep-sea dredging, could be designed and built to mine about 400,000 tons of phosphorite per year. At a sale price of $13.50 per ton of 29 percent phosphorite, the indicated return on this investment would be 52 percent per year after taxes. The estimated cost of mining is $4.50 per ton and the estimated cost of moving the phosphorite to a market is about $1.50 per ton.

The surface has hardly been scratched in the exploration of the world's oceans, but the process of gathering samples from the ocean bottom is vastly more complicated, time-consuming, and expensive than on land. Consequently, data are not rapidly being accumulated and analyzed. If Congress appropriates the $600 million over the next ten years that has been suggested by the National Research Council as a minimum amount necessary to be spent if this country is to maintain its present position of authority in the field of oceanography, a number of important discoveries concerning minerals on the sea floor will be made. Not the least of these discoveries will be that of mineral deposits which might easily repay the U. S. many fold for her investment and in a very practical way.

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BELT MAINTENANCE at West Kentucky Coal Co.

The best type of maintenance for belt haulage is preventive maintenance—which starts with the specifications for purchasing belts and belt drives and should exist through the life of the equipment

By BUDDIE R. MORRIS
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West Kentucky Coal Co., Inc.

Frequent checking of splices is important. If a mechanical splice is installed properly and continues to pull out in a particular piece of belt, the belt should be checked for rotting and deterioration

IN West Kentucky Coal Company's six operating mines, various types of haulage from the shuttle car discharge point to the surface have been employed.

In four of the six mines there is a combination of belt and track haulage. To explain this system briefly, panel belts discharge onto a gathering belt which carries the coal to a loading point where it is transferred to mine cars to be hauled to the slope bottom. Here the coal is dumped from drop bottom cars into hoppers ranging from 250 to 500 tons capacity. The coal is then moved by feeders onto a slope belt which discharges on the surface.

All-belt haulage was first introduced in the company at the North Diamond mine in 1940. This mine operated from 1940 to 1950, producing approximately 4200 tons of washed coal daily with seven operating units. The belt haulage consisted of 42-in. gathering belts and 30-in. panel belts. Valuable information was obtained from this first all-belt operation, which enabled management to train its supervisors and belt mechanics for a belt maintenance program.

At present, the company has two mines operating with all-belt haulage, i.e., East Diamond and Pleasant View. Both mines have belt haulage systems exactly like the North Diamond operation, with the exception of some 36-in. panel belts that were purchased after these two mines were placed in operation. Both mines produce from 8600 to 10,000 tons of ROM coal daily with eight operating units. Practically all of the information and figures quoted in this article were obtained from these two mines.

Everyone will agree that the best type of maintenance in any coal mine today is preventive maintenance. It is especially important in belt haulage. If the haulage system ceases to function, it may, as in West Kentucky Coal's case, cost as much as $3900 per hour. Preventive maintenance for belt haulage starts with the specifications for purchasing belts and belt drives and should exist throughout the life of the equipment.

Because this is a report on belt maintenance, the author will not go into the design of belts or belt drives. However, a company must have the proper belt and drive to do the selected job.

Design Safety Factor—140 Percent of Average Tonnage

In the purchase of new belt West Kentucky Coal includes a safety fac-

tor in determining the maximum load that the belt will carry. This is done in the following manner. By experience the company has found that in order to obtain an average tonnage it must be equipped to profit from the periods when tonnages are produced over and above the average tonnage. Obviously it cannot afford to spend the money to haul the highest possible tonnage, which may be 200 percent above the average. Experience has indicated that the company should be able to haul 140 percent of the average tonnage, and the newer belts have been purchased to do just that. Tension ratings are based on a tonnage factor of the average, plus 40 percent.

In purchasing belt drives the company specifies that the head frame be symmetrical so that all sprockets and gears can be used on either side, and the drive can be placed on either side, depending on which side is easier for installation or easier to reach from the supply track if parts are to be changed.

All 42-in. belt drives are purchased with horizontal take-ups to reduce installation and maintenance cost. With horizontal take-ups there is no vertical excavating to be done, and the take-ups are easier to reach for checking and repairing. The installation of horizontal take-ups costs about $700, whereas the cost of excavating for vertical take-ups is approximately $2400.

The shafting for all 42-in. belt pulleys are specified to be the same size and design so that all shafts in the system are designed to take the maximum load. With all shafting the same, if the shafts on the primary pulley should break, or if the belt were to slip on the primary pulley, then the shaft on the secondary pulley would take the additional load. Also, by having all shafts, gears and pulleys interchangeable, the company has an advantage in that it can keep a smaller inventory of parts in stock.

Various Protective Devices Employed

In the installation of each belt drive there are electrical devices installed to give protection against belt slipping, sequence failure, chute plugging and full bin protection. A centrifugal switch is placed in series with the starting switch and in contact with the belt so that if the belt slips on the drive pulley, the circuit is broken. Also, centrifugal switches or sequence switches are placed so that when the main line belt is stopped, each secondary belt will stop in sequence. Paddle switches are installed at each transfer point and in the event the chute becomes plugged, or the bin is full, the overflow of coal will trip the paddle switch and break the circuit stopping the belt. Proper acceleration rates, contact points, and control apparatus are checked weekly. A pilot line consisting of two low voltage No. 16 single conductor wires are placed over the belt and parallel to the belt for protection against roof falls and for emergency stopping.

Some of the earlier 42-in. belt drives purchased by West Kentucky Coal utilized squirrel cage induction motors. It was soon discovered that the mines were having excessive trouble with these particular motors; therefore, fluid couplings were bought and installed to reduce the starting torque. This increased motor life considerably. Now, all drive motors purchased are of the wound rotor type.

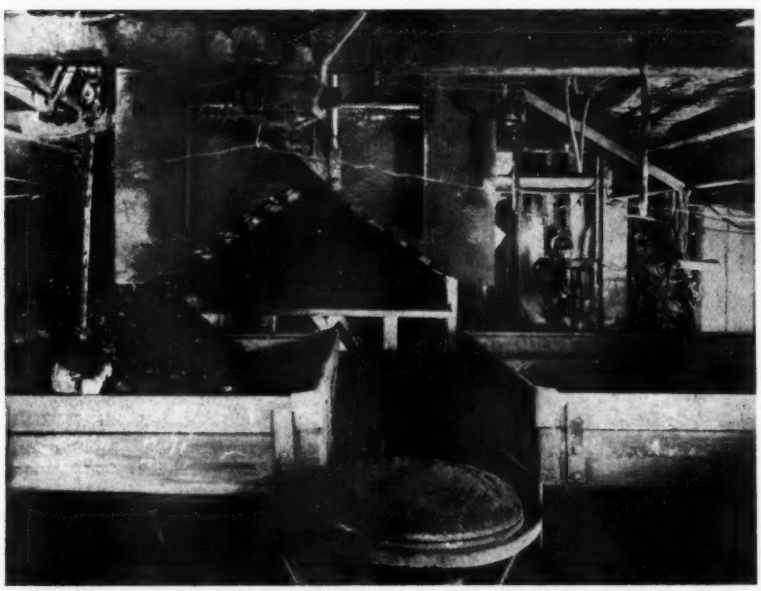
All transfer points are well lighted, and a telephone and control station is placed at each transfer station. Well-constructed chutes and impact rollers are placed at each transfer point, thus reducing the force with which the coal strikes the receiving belt, thereby causing less damage from impact and also less spillage, especially where the coal changes direction of travel. Also, the transfer of coal from one belt to another is made between idler stands and not directly onto an idler stand. The transfer point should be designed to cause a minimum stopping of the belts. This will extend the life of the belts and the electrical components, not to mention the increased tonnage.

Belt Lines Inspected Each Shift

Each drive is visited monthly by a belt mechanic to grease and inspect motor bearings and drive bearings. At the time of this inspection the dust is removed from the motor with a hand vacuum cleaner. This particular job is done whenever necessary; the company has cleaned them as often as once a week. The oil in the speed reducer is changed every six months.

The belt lines are inspected each shift by a belt mechanic. In this particular inspection the mechanic checks the belt alignment and the top and bottom rollers. The rollers that are bad are marked and changed as soon as possible. In the inspection of the rollers, particular attention should be paid to the return rollers. These are the most likely to be overlooked since they aren't as easily inspected.

It has been the company's experience that the return rollers wear out faster than the top rollers—probably because the return rollers are not as easily inspected. The fine material sticking to the belt is deposited at these rollers causing a build-up of fines which wear out the shell of the rollers. This not only causes a maintenance problem, but also creates a fire hazard. West Kentucky Coal's percent of replacement on top rollers is approximately one percent per year, while the percent of replacement on the return rollers is ten percent per year. The rollers are greased every six months.



A 1600-tph transfer point designed for a minimum of belt stopping and to increase belt life and production

Frequent checking of belt alignment is most important in preventive maintenance. If belt misalignment is allowed to continue for any length of time, the edges of the belt will begin to wear, causing the belt to separate. Edgewear will also allow moisture to seep into the belt structure, causing rotting and deterioration.

Misalignment may be the result of several factors—tailpiece not installed properly, bottom swelling, frame knocked out of line, framing assembled out of square, off-center loading, or crooked belt. When framing is assembled out of square, excessive friction is placed into the assembly by having to "slant" too many rollers in order to properly train the belt. This particular problem was encountered at one of West Kentucky Coal's belt installations. A considerable increase in power consumption was noted at one of the belt drives, indicating an increase in frictional drag or load in the system. It was then discovered, after many hours of inspection, that several sections of belt framing were assembled out of square. The frictional factor went as high as 0.055. Framing is now purchased which cannot be assembled out of square and the frictional factor is kept to 0.035.

Adjust Troughing Idlers To Train Belt

Assuming the belt framing, head and tail pulleys are installed properly, then the process of training the belt is a simple adjustment of the troughing idlers. The adjustment in the idlers may be made by what is commonly known as "knocking idlers" or by tilting the troughing idler forward. Training the belt by knocking the idlers means, simply, shifting the idler axis with respect to the path of the belt. The belt is centered by knocking ahead (in direction of belt travel) the end of the idler to which the belt runs. However, one should be careful to knock the idlers over a considerable length of the conveyor. In tilting the troughing idler to center the belt, the troughing idler must be tilted forward in the direction of belt travel. The tilting method produces a good self-aligning effect, but the idlers must not be tilted over two degrees. In the company's 42-in. belt installations, self-aligning idlers are often used on both the top and bottom sides.

After the belt has been properly trained, it is important to see that the coal, when discharged onto the belt, is loaded as near the center of the belt as possible. Off-center loading will have a tendency to make the belt run to one side.

Belt cleanliness is necessary for good maintenance. For example, spilled coal piled around rollers can become packed and wear them out

Good Housekeeping Pays

One of the most important steps in preventive maintenance for belt haulage is cleanliness. It is essential that all transfer points, headers, belt line, tailpiece and shuttle car ramps be kept clean of spilled coal or oil. Spilled coal piled around rollers will become packed and wear out the rollers. As a result, the belt will slide over the rollers and coal causing excessive friction and wear. Coal being carried back into the tail section will often hang the belts and cause them to pull in two. Oil on the belt will cause the belt cover to swell or the belt center to rise off the troughing idlers. To keep the belt itself clean, a rubber scraper is placed on the bottom side of the belt just behind the head pulley to remove the fine coal that sticks to the belt. Also, there is a plow installed in front of the tailpiece on top of the return side of the belt to remove any coal that has been spilled on the return side of the belt before the coal is carried into the tailpiece.

To show how West Kentucky Coal feels about belt cleanliness, in a typical eight-unit mine, double shifting, there are approximately 33 men employed as belt cleaners and header men at a cost of approximately ten cents per ton of coal mined.

Mechanical Splices Used Only in Temporary Installations

All mechanical and vulcanized splices are made to Goodyear specifications. Vulcanized splices are used in belt installations that will be in operation for one year or longer. Mechanical splices are used in all temporary installations that will be moved within one year after their installation.

In making the mechanical splice, several types of fasteners are satisfactory. The particular type that West Kentucky Coal uses is a hinged bolted plate type. When using this type of fastener, care should be taken to see that the ends of the hinge pin are properly fixed so as not to hang on anything while the belt is in operation, and the corners of the belt at which the splice is made should be properly trimmed. After the splice has been made, and the belt has operated for a shift, the bolts are retightened to prevent loose bolts from causing a pullout. After approximately one week the bolts are tightened again. If the mechanical splice is installed properly and continues to pull out in a particular piece of belt, then the belt should be checked for rotting and deterioration.

As stated previously, all vulcanized splices are made to Goodyear specifications. The company has practically standardized on a diamond splice with a six-in. step. In making these splices, particular attention must be paid to their alignment. The company's standard tolerance for a vulcanized splice is $\frac{1}{8}$ in. in 25 ft on either side of the splice. In making a vulcanized splice the stripping down is done with a Baker Jeep rather than by hand. Cuts are made and the belt stripped back far enough for a clamp to be placed on the belt. Next, a cable is attached to the clamp and run through a series of pulleys to the Jeep

in a nearby crosscut which pulls the strips off. With this method of stripping the job is done in about 30 to 45 minutes.

Delays Have Been Low

This maintenance program may seem rather expensive at first glance, but if the costs are compared to the results, it will be found that West Kentucky Coal has a good return on the money invested in its belt maintenance program. The following is a breakdown of the maintenance and operating cost of labor and supplies of one of the company's all-belt mines.

30-In. Belt Conveyors	
8 drives—12,780 lineal ft of belt	
6390 lineal ft of framing	
Cost/ton ROM	**$0.080**
36-In. Belt Conveyors	
1 drive—3200 lineal ft of belt	
1600 lineal ft of framing	
Cost/ton ROM	**$0.14**
42 In. Belt Conveyors—Main Line Haulage	
7 drives—25,100 lineal ft of belt	
12,550 lineal ft of framing	
Cost/ton ROM	**$0.053**
Lubrication	**$0.004**
Total cost/ton ROM	**$0.151**
Cost/ton mile	**$0.071**

As a result of this maintenance program, the company has experienced for a two-year period a delay time of only 0.59 percent on the panel belts and an average of 0.57 percent on the 42-in. main belts, or a total of 1.16 percent delay time on its belt haulage. With 6½ hours per shift at the face, this is a total of ten minutes per operating day, or approximately $65 per day loss due to belt delay. What would be the delay time without the maintenance program? Well, this point can be argued, but the writer knows of some mines that have had a belt delay as high as ten percent.

It is difficult to say what the average life of the company's belt has been. Some of the 42-in. belts have been in operation 19 years. The replacement of 42-in. main line belt has been about 1000 ft since 1940, or an average of 0.14 percent per year.

Some panel belts in operation now have been operating from nine to ten years. Replacement on panel belting indicates about 5.9 percent per year.

In checking the records for the last three years, it is found that the rate of replacement of rollers used on panel belts has been 1.0 percent for top rollers and 9.0 percent for return rollers. The replacement on 42-in. main line belts for rollers is 1.2 percent per year on top rollers and 10.4 percent per year on return rollers.

ROOF CONTROL

Detecting Loose Roof*

Prehistoric man had to be constantly alert in order to protect himself from wild animals and the ravages of nature and to provide himself with food and shelter. Living in a cave as he did, early man had his problem of roof control, just as coal miners have today. We can picture the bearded caveman using his sense of sight to detect loose rock in the roof of his hillside home, or listening for tell-tale sounds while banging the roof with a heavy stone or a large bone from yesterday's meal.

With the passing of centuries, the problem of detecting loose roof in caves and mines is still with us. Many articles have been written on the subject, and speeches given by experts, but with all such background we often fail to exercise caution. We know how to prevent roof falls, but we frequently neglect to use our senses in simple effective ways for testing roof.

Education in testing roof is very simple. A miner easily learns to use his sense of sight to check roof irregularities and the action of the roof on timbers. He also learns to use his sense of hearing to listen for unusual roof noises and to "sound" the roof.

Sounding is done by striking the roof with a heavy instrument such as a bar or, preferably, a roof testing tool. The quality of the sound indicates the stability of the roof. If the sound is hollow or "drummy," the roof is loose and requires supporting or taking down. However, a sound that is not "drummy" does not mean that the roof is absolutely safe. If a dangerous piece of roof is thick, for example, it may not give off the characteristic hollow or "drummy" sound.

Inasmuch as the condition of the roof cannot always be determined by sight and "sounding," another method should be used in conjunction with these two. This method brings the sense of touch into play. It is known as the vibration method, and often is considered more dependable than sounding alone. To use it, the bare fingers of one hand are placed lightly against the roof and, using the free hand, the roof is struck hard with a suitable testing tool. The vibration of the roof against the fingers indicates the condition of the immediate roof.

The condition of certain types of roof makes it difficult to utilize the sight, sound, and vibration methods. The roof may contain "kettle bottoms," "horsebacks," rolls, clay veins, or other conditions that may make testing difficult. These irregularities often may be concealed by a thin layer of coal, giving the appearance of good roof, and an examiner may miss the danger completely while testing. Because conditions like these can exist, a strict, systematic timbering standard and unrelenting enforcement are essential.

All underground workers should be taught the methods of testing roof, and all operating companies should adopt rules requiring that the roof, face, and sides of working places be inspected at frequent intervals. Too, the company should have an approved systematic timbering plan worked out from experience for the guidance of its workers.

A worker should be made to understand that in most instances it is the apparent "good" roof that kills, and that he must be ever on the alert to check the condition of the roof under which he works. He must be made to understand that he cannot afford to gamble by taking unnecessary chances. The stakes—his life and the lives of his fellow workers—are too high!

** Prepared by the Advisory Committee 1960 National Campaign to Prevent Injuries From Roof Falls in Coal Mines.*

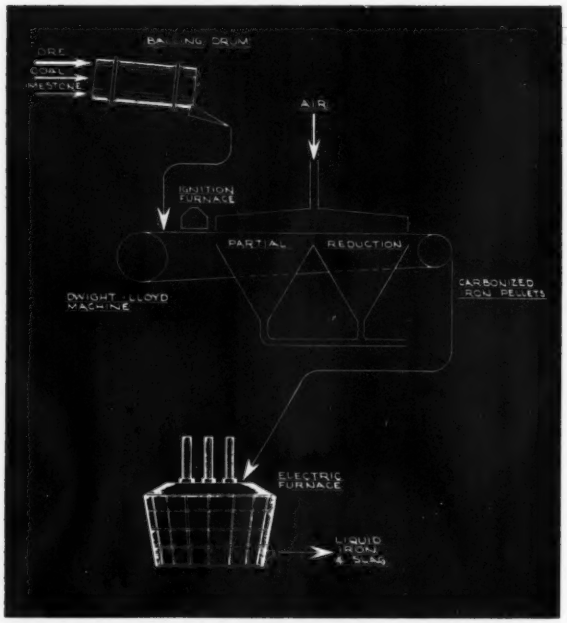


Fig. 1. Continuous making of pig iron by the Dwight-Lloyd McWane process

Iron Making by the Dwight-Lloyd McWane Process

By ROBERT C. McDOWELL
President
McDowell Co., Inc.

DWIGHT-LLOYD processes were originated in Mexico 52 years ago by the invention of the continuous sintering process as a means of beneficiating ore minerals for blast furnace smelting. Since the early discovery, many other processing fields have been exploited. This article describes one of the more advanced methods of making iron that incorporates a Dwight-Lloyd process within a multi-stage system of smelting.

The history of metallurgy shows that many different types of machinery, apparatus and furnaces have been used for extraction of metals from ores. Early metallurgical practices in the western United States contributed to the development of the modern lead blast furnace, and copper blast furnaces have been replaced by reverberatory furnaces.

High temperature metallurgical operations generally include both reduction and melting of the ore mineral constituents. This type of operation applies the use of blast, reverberatory, and electric furnaces. Lower temperature metallurgical processes are usually performed in the solid state in well-developed reactors such as rotary kilns, traveling grates, rotary hearths, and fluo-solids reactors.

The blast furnace, as commonly applied to modern lead and iron making processes, exists as an efficient, perfected, smelter that is traditional. Perhaps the electric furnace competes as the only other type of smelter to receive prominent consideration for iron smelting.

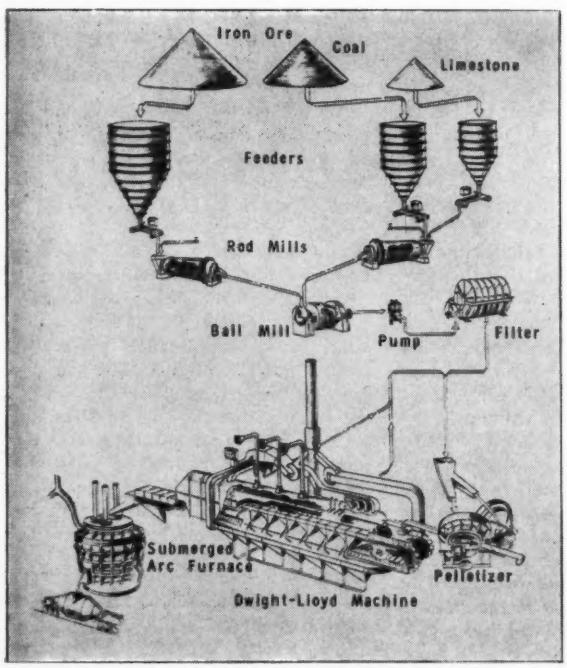


Fig. 2. General arrangement of 2200 tpd (net) D-LM pig iron plant

Blast Furnace Material Requirements Partly Inflexible

A blast furnace may be described as a smoke stack equipped with tuyeres for blasting air into the bottom portion of the stack. By charging sized and prepared ore minerals, lump metallurgical coke, and flux into the stack, the raw materials are admitted to the blast furnace countercurrent to the blast of gases. Partial combustion of the coke provides both heat and reducing gases, the latter of which effectively extracts oxygen from the minerals. The heat of combustion pro-

vides energy for driving the reactions and liquifying the materials as hot liquid metal, which is purified by trickling through a liquid slag layer.

For technical reasons, the basic raw materials for blast furnace smelting require pretreatment. The metallic minerals should be desulphurized and consolidated into a lump or agglomerated form in order to allow passage of great volumes of gas through the stack. The heating and reducing agent, coke, must be produced from special grades of metallurgical coals in order to form stable, coherent blocks.

Coke within a blast furnace occupies almost 50 percent of the volume and acts as a thermally stable nest for the ore minerals. The nesting is relatively unaffected until the charge descends to the tuyeres, where partial combustion of coke and liquification of the charge is accomplished. The flux, usually as limestone, is either charged in the lump form or is previously intermixed with the ore minerals as self-fluxing sinter.

Blast furnace processes illustrate a form of metallurgy wherein basic raw materials are altered in order to conform to requirements of the metallurgical apparatus. The Dwight-Lloyd McWane process, as described herein, is the diametric opposite; that is, it is a method of altering metallurgical apparatus in order to conform to specifications of the basic raw materials.

Development of Dwight-Lloyd McWane Process

The Dwight-Lloyd McWane (D-LM) process was developed from a multistage cast iron making process perfected at Battelle Memorial Institute, working under the sponsorship of McWane Cast Iron Pipe Co. Dwight-Lloyd equipment and services were applied in the development. After the termination of the basic research project, McDowell Co., Inc., agreed to further research by pilot plant work, and to administrate and market the novel iron making technique known as the Dwight-Lloyd McWane process.

The production of self-fluxing sinter has been widely discussed as a great metallurgical stride in beneficiating raw materials for blast furnaces. Although reports were in circulation in the United States more than 30 years ago illustrating benefits of self-fluxing sinter in lead blast furnace practice of the western U. S., more recent reports unfortunately implied that self-fluxing sinter applications were developed first by the ferrous blast furnace practices of the Soviet Union. The D-LM process illustrates production of highly beneficiated feed for a smelting furnace that is not only self-fluxing but is prereduced, precalcined, preheated, and indeed self-reducing.

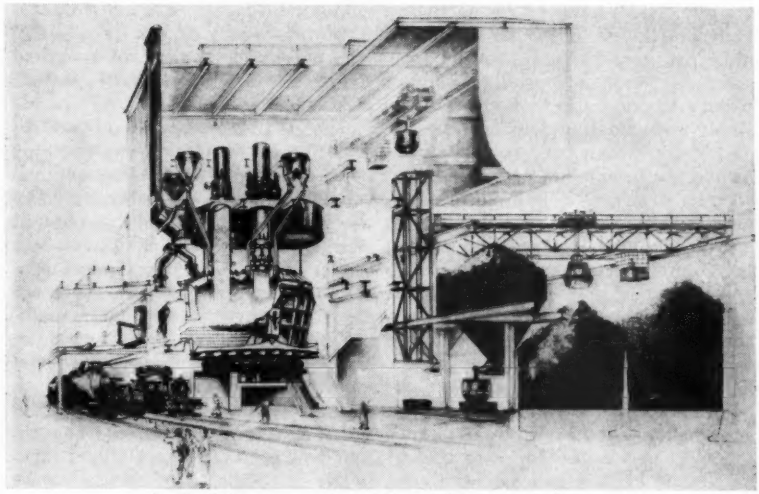


Fig. 3. Melting iron ore in a submerged arc electric furnace

The simplified flow sheet in figure 1 illustrates continuous making of pig iron by the D-LM process. It shows proportioned quantities of basic raw materials—iron ore fines, slack non-coking coal, and limestone fines — blended, pelletized, prereduced, and lastly smelted. Usually raw materials of a fineness of minus 20 mesh are required to produce a pellet of desired qualities for processing.

Drying and Sintering of Pellets

If sufficient quantities of fine materials are readily available, such as fine iron ore concentrates and flotation coal, grinding may be obviated, and the raw materials are directly pelletized. However, either dry or wet grinding may be necessary. For these purposes, the wet grinding circuit is illustrated by figure 2, which indicates dewatering by a vacuum filter and balling by rotary balling devices. The moist balls or green pellets represent composite "pills" which contain the requisite metallurgical quantities of powdered coal, ore, and flux in a compact form. In this physical state the green pellets are amenable to extremely rapid metallurgical reactions within a packed bed.

Green pellets charged to the Dwight-Lloyd machine enter a drying zone that expels pellet moisture through use of hot recirculated draft. Next, the layer of dried pellets is ignited by a stationary torch as the thin bed continuously moves beneath it. Immediately after ignition, the bed is subjected to carbonizing reactions induced by partial combustion of the coal.

It is important to point out that within the carbonizing zone of the Dwight-Lloyd machine, three very important phenomena occur: (1) the iron oxide minerals become reduced approximately 50 to 65 percent; (2) the limestone becomes calcined; and (3) the coal constituents become converted to a hard pyrolytic char. This char acts as the pellet bond and resembles in miniature the coke nest within the blast furnace.

The carbonized pellets emerge from the sintering machine as red-hot, individual specimens of a composite smelter burden that are self-fluxing and self-reducing. Physical and chemical properties of this material typify a very highly beneficiated burden for a smelter.

The burden is thermally beneficiated inasmuch as it is charged at approximately 1500°F. It is chemically beneficiated inasmuch as it is prereduced and precalcined. It is physically beneficiated inasmuch as it possesses a porous pellet structure that is receptive to gas-solid reactions.

The carbon bond within the pellet possesses high chemical reactivity and high electrical resistance, both of which assist electric furnace smelting. Figure 2 illustrates continuous charging of carbonized pellets to the electric smelting furnace which is intermittently tapped for liquid iron and slag.

Beneficiated Feeds Improve Smelter Economics

Iron smelting economics have been improved markedly within the past

decade through use of beneficiated feed. Generally speaking, beneficiated feed contributes to smelter capacity and fuel conservation. Self-fluxing sinter as a beneficiated feed shows furnace economies to be improved by simply consolidating fine ore minerals with flux. Extensive beneficiation beyond the production of self-fluxing sinter is expected to improve economies of smelting to a remarkable extent. The highly beneficiated feed of the D-LM process brings this into realization.

The practice of smelting iron ore with a submerged arc electric furnace is illustrated in figure 3, which shows the charging, smelting and tapping facilities for a typical electric pig iron smelter. The furnace used herein is known as a closed top submerged arc electric furnace and has been applied extensively on the North American continent for making ferroalloys, calcium carbide and phosphorus.

This electric furnace practice is also known as electrothermal reduction and is performed by continuously charging ore and coke into a crucible that contains vertical electrodes. Electrical energy dissipated from the electrode tips as buried arcs causes extreme temperatures to prevail which induce the high temperature metallurgical reactions.

The conventional submerged arc electric furnace smelting a mixture of self-fluxing sinter and coke uses lesser quantities of coke than the conventional blast furnace because heat is supplied by electrical energy. The electric furnace also has a much lower stack height than the blast furnace, thus minimizing structural requirements of the burden. Gas emanating from the conventional electric furnace smelter is relatively rich in calorific value because no nitrogen is introduced into the furnace.

Electrical Requirements of D-LM Process

Electric smelting has been applied for making iron in areas having abundant sources of electrical energy but lacking sources of coke. Complete steel works which use this system predominantly for making basic hot metal have existed for a number of years in Norway and in Italy. Smaller furnaces exist in other countries and are used for the production of merchant and cast iron.

Generally these furnaces have electrical energy requirements of 1900 to 2500 kwh per ton of metal. They also require charged burdens comprised of either sinter or lump ore and coke. In some cases anthracite and lower qualities of fuel are used in lieu of coke. The larger electric furnaces have transformer capacities of 30,000 kva, possess electrodes that are about five ft in diameter and have production capacities up to 220 tpd of iron.

The D-LM process may be described as a system using highly beneficiated feed for the conventional submerged arc electric furnace. The use of preheated and prereduced charge that is self-fluxing and self-reducing obviously offers metallurgical advantages for the submerged arc electric furnace.

Production records show that the D-LM process will produce hot metal or pig iron for about 800 to 900 kwh per ton instead of the 1900 to 2500 kwh per ton records of the conventional furnace. The capacity of identically sized electric furnaces shows the D-LM application to have productions of about 500 to 600 tpd as compared with 200 to 220 tpd for the conventional furnace.

Proven Metallurgical Apparatus Used in Process

The flow sheet of figure 2 illustrates basic raw materials, such as ore screenings, limestone screenings, and slack varieties of noncoking coal, to be used in the D-LM process. These inexpensive raw materials can be compared with the prepared burdens of self-fluxing sinter and coke for the conventional electric furnace smelter.

Application of proven metallurgical apparatus is an outstanding feature of the D-LM process. Grinding mills are used in almost all of the ore dressing and cement plants of the world. The balling or pelletizing equipment has been proven by the taconite industry to a scale that currently approaches 10 million tons per year.

The use of the Dwight-Lloyd machine in more than fifty years of metallurgical processing has been widely advanced to a stage where more than 60 million tons of material are processed annually by continuous sintering machines in North America alone. Individual machines having tonnages exceeding 5000 tpd are in common usage. The types of submerged arc electric furnaces described previously have been in operation for a great number of years in many different countries to produce many different kinds of products.

Figure 4 is an engineering drawing of a complete smelter of 2200 tpd capacity for making iron by the Dwight-Lloyd McWane process. It can be readily noted that the raw materials handling facilities are very similar to those of conventional sintering plants; the milling and pelletizing circuits are similar to those of established pelletizing plants; and the electric smelting system is similar to that of many electric furnace smelting plants. The novelty of arrangements and operations of these separate entities encompass the entire Dwight-Lloyd McWane process.

Figure 4 illustrates that unit construction of plants can be expanded to multi-units having common ore yard and common hot metal handling facilities. This type of construction and expansion parallels ore concentration plants generally limited to separate milling capacity systems. Practical limitation of a single unit D-LM plant is probably determined by the size of electrodes for the electric furnace. Figure 4 indicates equipment sizes presently in use in various metallurgical operations.

Raw Materials Costs—a Major Factor

Economics of iron making by any method are largely determined by delivered raw material costs, which can readily account for more than 70 percent of finished iron production costs. For this reason, geographical locations of smelters influence production costs, as well as marketing and transportation; hence, materials handling or transport costs become dominant factors in profit margins. Low cost Great Lakes transportation from Lake Superior iron ore mines, and convenient rail haulage of mid-central coking coals have brought about relatively centralized iron and steel producing centers in the U. S.

Unique methods of making iron from various types of raw materials, which previously required beneficiation, could cause some geographical shifts of the centers of iron making. The processes which include noncoking coals, natural gas, and electrical energy as principal raw materials can readily profit from sites in regions where these types of raw materials occur plentifully.

Assurance of economic profitability of all new processes requires extensive research. The chemical and electrical industries have illustrated the importance of fundamental research in this respect.

Applied research and pilot plant investigations are principal forms of economic insurance for new processes in the basic industries and are extremely reliable for determinations of flow sheets; that is, raw materials qualities and quantities, and operation techniques. These should be

closely coordinated, however, with the engineering assessment of scale-up factors, materials of construction, and plant layout for minimizing maintenance and labor requirements. Availability or "operating time" of a commercial plant, for instance, is the difference between profit and loss and requires simplicity and the scrutiny of engineering design.

D-LM Process Still Being Studied

Research investigations for the D-LM process began more than 11 years ago. Several pilot plant flow sheets have been applied to the process and are under continual activity at the Dwight-Lloyd Research Laboratories.

Many varieties of raw materials have been examined and many modes of operation have been applied for both technical and economic data. Lower grade iron ores, for instance, possess greater slag volumes and cause greater energy requirements. Also, the various qualities of coals influence the quality of the carbonized pellets. Minor changes in the techniques of preparation of the raw materials are usually determined by their nature. For instance, the D-LM circuit using fine iron ore concentrate would simply involve coal pulverization and blending with the concentrate prior to pelletizing, rather than the grinding circuit illustrated in figure 2.

Conservative and direct scale-up of the pilot plant data shows that an iron ore of 56 percent Fe can be smelted in a large scale commercial unit by expending 890 kwh per ton of basic pig iron. This electrical energy requirement was derived from inclusive and average data of a one week campaign, and it is to be expected that translation of the pilot plant data into those of commercial interest would correlate eras of high smelting efficiency. Also, this version would contain engineering assessments such as: (1) improved thermal efficiency in handling hot carbonized pellets in a commercial apparatus; (2) increased electric furnace shaft reactions in deeply loaded furnace columns; and (3) extension of high efficiency eras from operating proficiency and experience. By applying these factors, a more realistic version of smelting the above mentioned ore would indicate a 769 kwh requirement per ton of basic pig iron.

Effect of Plant Location on Economics

An economic evaluation, which includes the conservative values just mentioned, but does not include engineering assumptions which might be considered controversial, is presented in table 1. It shows the economic evaluations of projected Dwight-Lloyd McWane single-unit plants of 550 tpd basic pig iron capacity located in the St. Lawrence River area and the Lake Erie area, based on data obtained in a commercial plant operating at 95 percent of capacity.

These evaluations show considerable variation in production costs and return on investment due to plant location and costs of raw materials and power. A separate evaluation must be made for any location under consideration.

The production costs indicated in the Lake Erie area (table 1) are in the same approximate range as those for a new 3000 tpd blast furnace which was discussed at a meeting of the Electro-chemical Society in Chicago in May. Usually a complete blast furnace plant of this capacity requires capital investment on the order

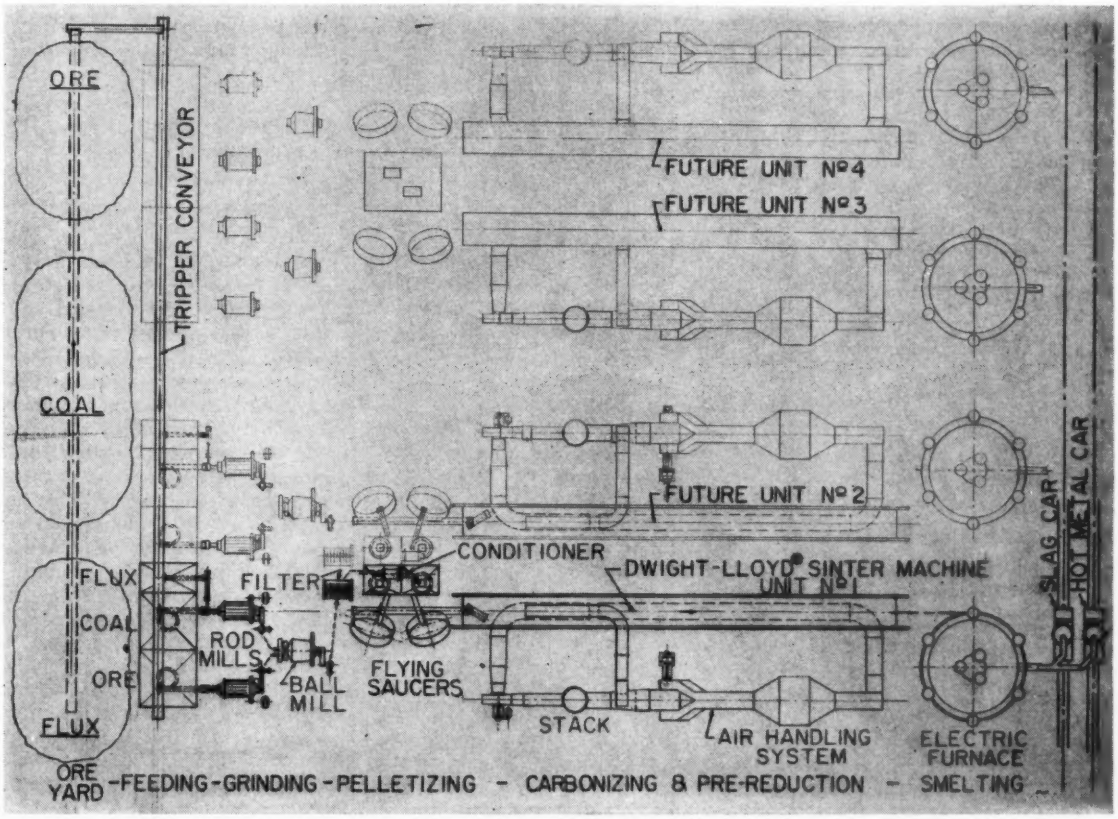


Fig. 4. Engineering drawing of a complete smelter of 2200 tpd capacity for making iron by the D-LM process

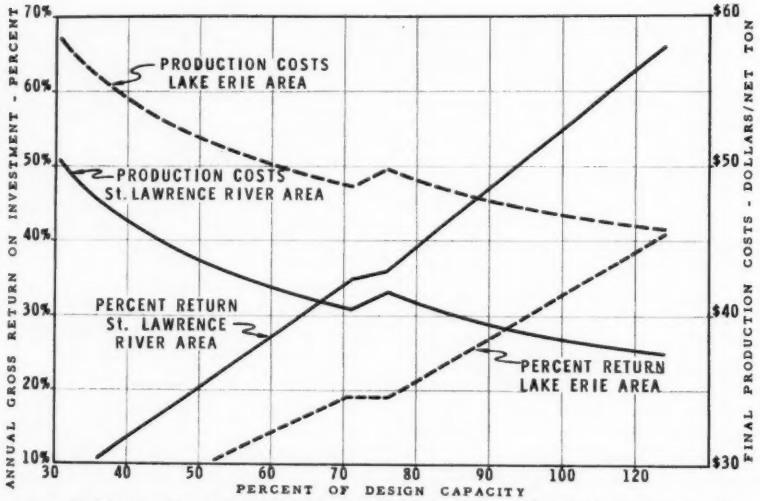


Fig. 5. Function of operating capacity on production costs and annual gross return of Dwight-Lloyd McWane plants in St. Lawrence River and Lake Erie areas

of $85 to $95 per annual ton. The conventional electric furnace process, subjected to the same evaluation, and having about one-half the blast furnace capacity would indicate production costs ranging from $50 to $60 per ton of pig iron, and would involve from $45 to $75 investment per annual ton.

It can be readily concluded from a study of these projections that a highly satisfactory return is apparent for a D-LM plant at either location at a capital investment of $35 to $40 per annual ton. Other studies based on a wide variety of geographical locations show generally similar economies.

The iron and steel industry has been historically subjected to variable operating capacities as dictated by market conditions, as well as by availability factors. Considerations of this knowledge are presented in figure 5, which illustrates the return on fixed capital investment for the above evaluated plants at various operating capacities. It is interesting to note that the single D-LM units, relatively modest in capacity by comparison with usual ironmaking facilities, show reasonable return on fixed capital investment even while operating in ranges as low as 50 percent of rated capacity.

Process Adapted to Producing Various Grades of Iron

Opportunities exist for relatively small producers for making iron by the Dwight-Lloyd McWane process. The plant can be initiated with single units of construction that can readily expand into multi-units after the product is thoroughly exploited in the market.

The versatile flow sheet allows various grades of materials to be incorporated and the flexibility of the operations allows various grades of product to be made. Basic hot metal, pig iron, white cast iron, grey cast iron, and silvery pig iron can be produced with reasonable facility from normal fine iron ores and noncoking quality coals.

The very rapid reactions within the Dwight-Lloyd system involving retention periods on the order of ten

Table 1. Economic Evaluation of Dwight-Lloyd McWane Process in a 550 TPD (Net) Plant (185,000 Net Tons Per Year) with a Fixed Capital Investment of $7,300,000

Raw Materials	Quantities	ST. LAWRENCE RIVER AREA Unit Cost	ST. LAWRENCE RIVER AREA Dollars Per Net Ton of Basic Pig Iron	LAKE ERIE AREA Unit Cost	LAKE ERIE AREA Dollars Per Net Ton of Basic Pig Iron
Iron Ore (56% Fe)	1.52 GT	@$9.50	$14.44	@$13.30	$20.22
Noncoking Coal	.84 NT	@ 9.00	7.56	@ 7.25	6.09
Limestone Fines	.20 NT	@ 2.50	.50	@ 2.50	.50
Electricity—Smelting	890 KWH				
—Auxiliary	60 KWH	@ .004	3.80	@ .00823	7.82
Electrodes	8.2 lb	@ .14	1.15	@ .14	1.15
Water	9,000 gal	@ .03/1000	.27	@ .03/1000	.27
Supplies			.76		.76
TOTAL COST OF RAW MATERIALS			$28.48		$36.81
Labor	.95 man hr.	@ 3.34	3.17	@ 3.34	3.17
Indirect, Maintenance, Payroll and Fixed Costs			5.92		5.92
TOTAL PRODUCTION COSTS			$37.57		$45.90
SALES AND DISTRIBUTION			1.18		1.18
FINAL COSTS			$38.75		$47.08
SALES PRICE			$58.93		$58.93
GROSS PROFIT			$20.18		$11.85
INVESTMENT PER ANNUAL TON			$39.46		$39.46
ANNUAL GROSS RETURN ON INVESTMENT			51.14%		30.03%

minutes allow immediate burden changes to influence the quality of iron and slag, thus minimizing off-casts. Ferro-alloy production by D-LM is readily accomplished. The extent of prereduction is limited by thermodynamic considerations wherein reactions up to 2200°F can be accomplished on the carbonizing machine.

Application of the Dwight-Lloyd McWane process in the western areas of the U. S. is of considerable interest. Relatively small localized sources of iron ores, enormous reserves of noncoking coals, and the abundance of hydroelectric power in the northern districts are attractive raw material sources. Marketing of iron products in sparsely populated areas, however, deserves attention.

Large foundries, such as cast iron pipe manufacturers, and engine block producers, for example, take interest in integrated works for producing finished goods. In this respect, the shipment of finished products from mine site locations parallels the nonferrous industries in the western states. With the advent of ductile cast iron, it is anticipated that ductile cast iron products will be competitive with certain rolled steel products. Decentralization of the iron and steel industry is important to our national economy and security. These factors are among sound economic reasons which compel the growing interest in the commercialization of D-LM iron-making.

Engineering and Pilot-Plant Studies Continue

The Dwight-Lloyd McWane process is covered by U. S. and foreign patents and patents pending in its essential features. McDowell Co. is continuing to improve the economics beyond those presented herein.

Many features of machinery design, arrangement systems, and process diversification are being examined and developed. For instance, pilot plant investigations have shown that considerable shaft reactions occur within the pellet column above the electrodes to provide approximately three times as much carbon dioxide as is ordinarily acquired by the conventional electric furnace process. This suggests the possibility of feeding the electric furnace by unique methods which are being examined from engineering standpoints. An economically sound process should provide avenues for development so as to utilize our evergrowing technology. The Dwight-Lloyd McWane process fulfills this requirement.

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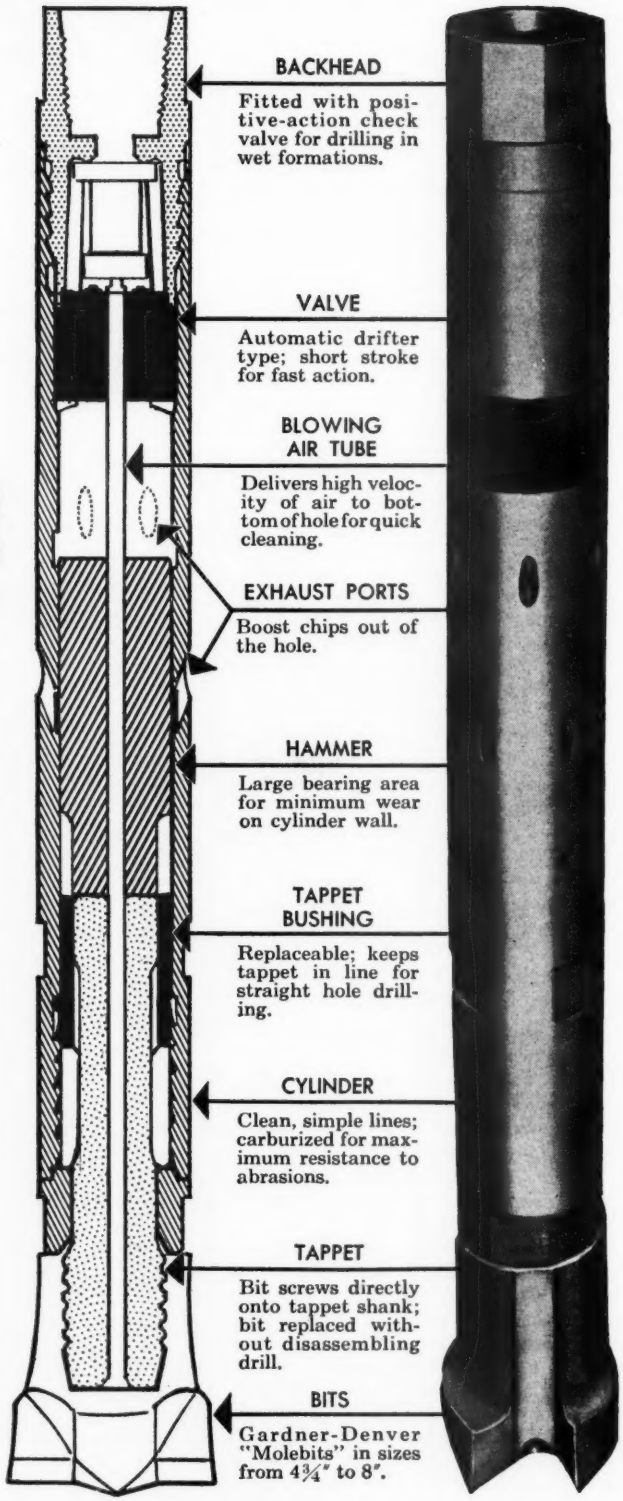
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VALVE
Automatic drifter type; short stroke for fast action.
BLOWING AIR TUBE
Delivers high velocity of air to bottom of hole for quick cleaning.
EXHAUST PORTS
Boost chips out of the hole.
HAMMER
Large bearing area for minimum wear on cylinder wall.
TAPPET BUSHING
Replaceable; keeps tappet in line for straight hole drilling.
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Clean, simple lines; carburized for maximum resistance to abrasions.
TAPPET
Bit screws directly onto tappet shank; bit replaced without disassembling drill.
BITS
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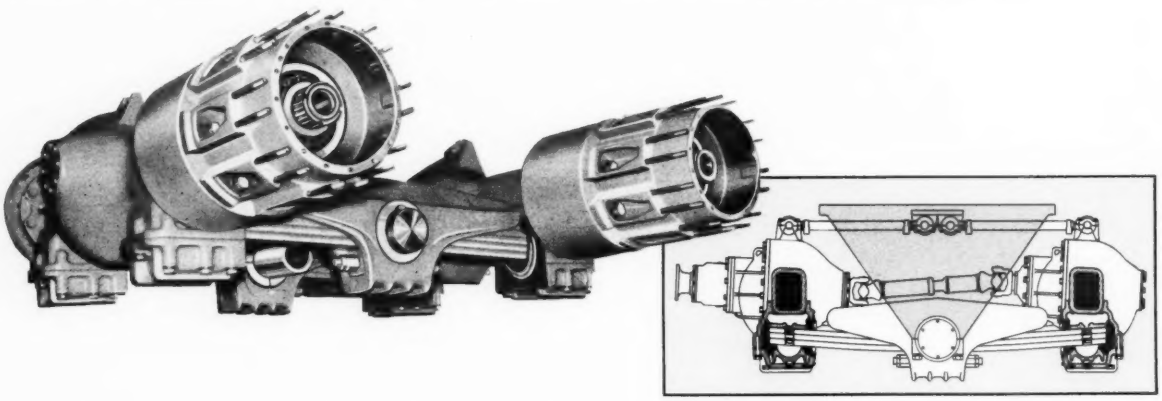
NEW—from radiator to bogie

Mack M Model

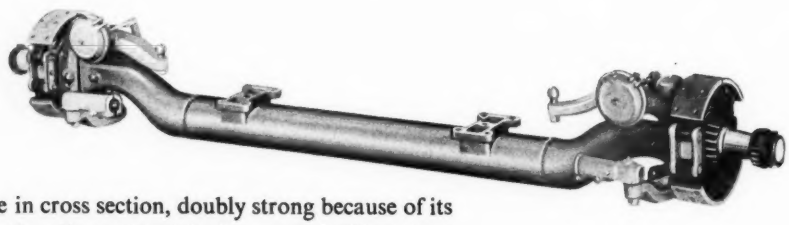
made for mining with mining-duty components

Meet the matchless Mack M Model—made to take in stride the heaviest hauling of the mining industry. Successor to the highly successful Mack Model LYSW, the new 45-ton M Model offers many of the proved features that won its predecessor a worldwide reputation for lowest operating costs and remarkably great freedom from downtime.

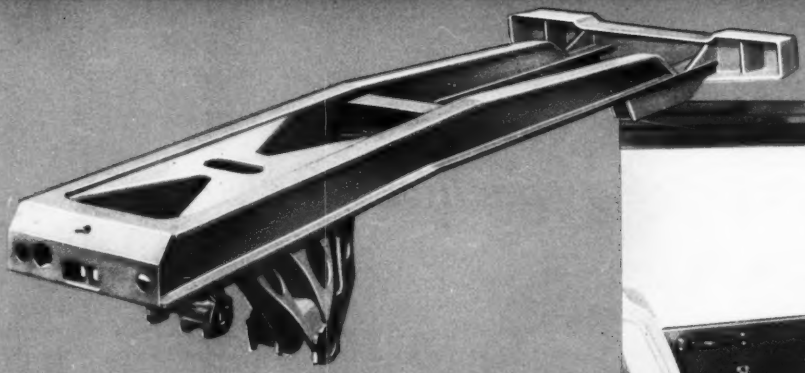
Add the new features shown on these pages, improvements that give still greater vehicle life and operating economy, and you have a vehicle destined to be first choice among users who demand the finest in heavy-duty hauling equipment.



New heavy-duty off-highway bogie. Unsurpassed for ruggedness and tractive ability and adding greatly to tire life, the newly designed Mack off-highway twin-axle bogie offers the strength and simplicity of straight-through drive and single-reduction carriers with Mack Planidrive reduction in the wheel hubs. Exceptionally long tire life is achieved through unusual bogie flexibility which also reduces twisting and wracking of the frame. Even with diagonally opposite wheels raised more than a foot each, this flexibility keeps all wheels equally loaded and the frame level. Suspension is through walking beam and flat leaf springs. In operation under load, the spring is in contact throughout the full length of the walking beam which contains it. Unloaded, the spring falls away from the beam to give as good a ride as when loaded. Spring ends are secured to the axles by rubber insulated rocker saddles which minimize friction, wear and rattling, cushion shocks and absorb vibration. Leaves are retained by wedges, thus replacement, if needed, is greatly simplified.

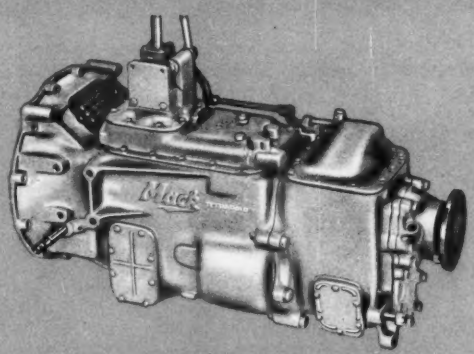


New 7″ tubular front axle. Massive in cross section, doubly strong because of its 7″ diameter tubular construction, the all-new Mack-built reversed Elliott front axle withstands the heaviest loads of extra-heavy-duty dumper-service. Wide in tread, it assures maximum stability and short turning radius.



Sturdiest, most durable frame you could ask for. Built to shrug off the jarring impacts of huge shovel loads, the all-welded special alloy steel frame of the Mack M-45 is of wide-flange I-beam construction. Three I-beam cross-members and cross corner gussets are welded to 16¼″ x 1″ main frame rail web to reduce stress concentrations in the flanges. Extra-rugged cast trunnion brackets are welded to web and 6″ x 1¼″ lower flange of main rails to avoid stresses in the flanges.

Designed to help you haul best. Modern in design, the new, bold lines of the Mack M-45 Model mark it as a truly functional heavy-duty dumper for the mining industry where huge loads are commonplace. Cab's reverse-slope windshield reduces glare and reflection . . . reduces dirt and dust accumulation. Cab doors are piano hinged for maximum strength, and the cab interior is double vented for driver comfort. New offset cab provides commanding view fore and aft for faster cycling, easier spotting and safer operation. Forward cab position permits shorter front-axle-to-back-of-cab dimension, so more weight can be shifted to newly designed larger capacity front axle without sacrificing cab roominess. Gages and instruments are conveniently grouped for visibility and quick reading.



Evenly-stepped, easily-shifted Mack Duplex transmission. Mack's exclusive two-lever eight-speed Duplex transmission, with air-assist clutch, matches perfectly the power output of the 450 hp diesel engine that powers the M-45, provides the proper ratios for heavy-duty service, and features exclusive Tetrapoid gears which are stronger, longer-lived and quieter than conventional gears. Gears are helical for easier shifting and quietness . . . involute transmission splines provide greater stamina and durability. Optional torque converter drives are also available.

Mack Model

Built to mining specifications

PAYLOADS: Rear dumper, 45 tons

WHEELBASE: 208"

PLATFORM LENGTH: 194"

OVER-ALL LENGTH: Front bumper to end of body, 380"

DIESEL ENGINES: 420 hp to 525 hp, 12-cylinder diesel engines

COOLING SYSTEM: 2330 sq. in. frontal radiator, continuous finned, flat tube; bolted top and bottom tanks; rubber mounted on center trunnion

ELECTRICAL SYSTEM: 12-volt, 40-amp.

STARTING: Air

TRANSMISSIONS: Mack, selective, constant-mesh, 8 speeds forward, 2 reverse; converter and Mack 4-speed transmission; Torqmatic converter. Optional integral hydraulic brake on torque converters

CLUTCH: Two-plate, air-assist with manual actuation

FRONT AXLE: Mack, heavy-duty tubular welded to cast ends

REAR AXLES: Mack off-highway walking beam bogie, single-reduction through-drive and Mack Planidrive, with final reduction through planetary gears within wheel hubs; inter-axle Power Divider

BRAKES: Front, air; rear, air-hydraulic; all rear wheels with separate air and hydraulic cylinders to prevent complete loss of braking in event of failure at one wheel; 12 cu. ft. compressor

FRAME: Alloy-steel, wide-flange I-beam, 138 section modulus

STANDARD BODY: Heavy-duty 100,000 psi alloy steel

CAPACITY: Struck, 28 cu. yd.; heaped SAE rating, 36.5 cu. yd.

SPRINGS: Front, semi-elliptic vari-rate, 3-leaf radius rod; rear, flat leaf in walking beam, suspended in rubber insulators

WHEELS: Cast, spoked

TIRES: 18.00 x 25, 24-ply tubeless on 13.00 rims

STEERING: Hydraulic power steering, 37½' turning radius

DUMP HOIST: Twin, double-acting, outboard mounted, three-section telescopic cylinder assembly, providing 65° dumping angle

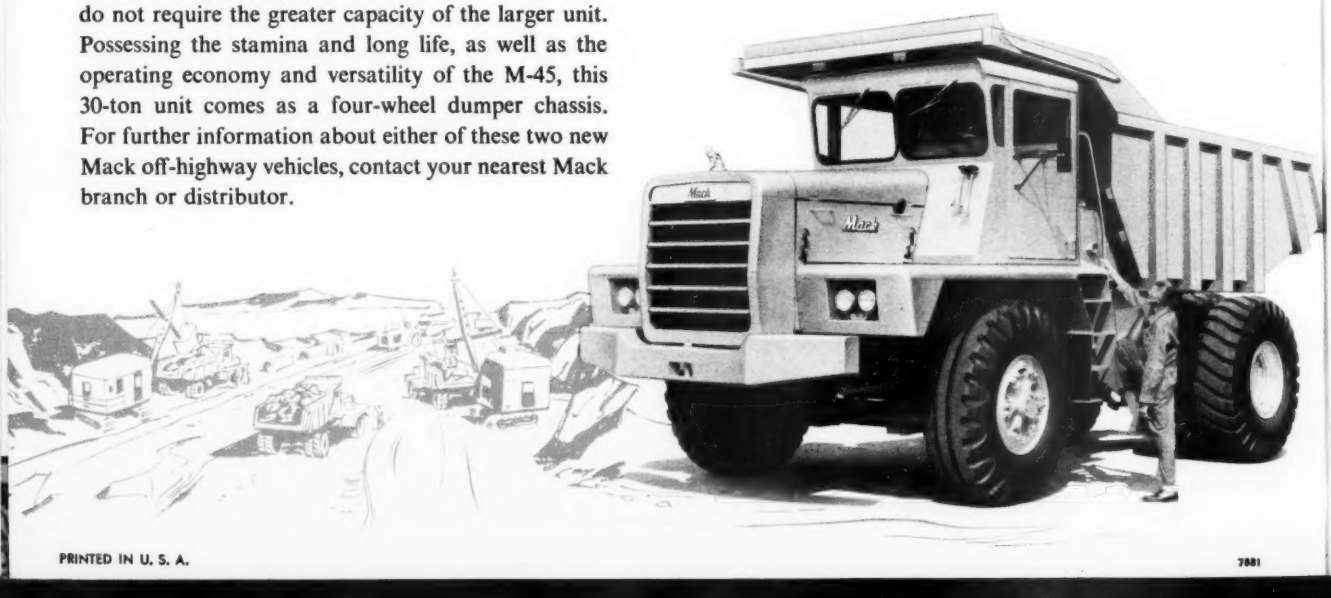
POWER TAKEOFF: Mack, 50 hp

OPTIONS: Heated body, rock ejectors

MACK FIRST NAME FOR **TRUCKS**

Mack Trucks, Inc., Plainfield, New Jersey • Mack Trucks of Canada, Ltd., Toronto, Ontario

Peerless performer—the 30-ton M Model. Mack M-30 Model, companion to the M-45, is offered to those in the mining, quarrying and construction industries who do not require the greater capacity of the larger unit. Possessing the stamina and long life, as well as the operating economy and versatility of the M-45, this 30-ton unit comes as a four-wheel dumper chassis. For further information about either of these two new Mack off-highway vehicles, contact your nearest Mack branch or distributor.



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The final portion of this report concludes that the apparent benefits claimed for legislated reclamation can be and are met equally well by voluntary reclamation practices performed by coal operators and others—and by nature itself

LAND RECLAMATION —PART II

By WALTER H. SCHOEWE
Head, Division of
Mineral Economics of Coal
State Geological Survey of Kansas
University of Kansas

PART I of this report, which appeared in the September issue of *Mining Congress Journal*, pointed out that six states have laws requiring coal operators to reclaim or rehabilitate their spoil banks. In reviewing these acts, the writer demonstrated that the reasons given for reclamation are, in the main, unwarranted, unrealistic and discriminatory. The final portion of this brief against compulsory reclamation will consider some of the effects cited as due to stripping and outline certain steps that the coal industry can follow to alleviate the pressure for legislative reclamation.

Stream Pollution

Pollution hazards may exist and if so they should be remedied at once. In Kansas only one case of actual water pollution of a stream associated with the coal industry is on record. In Cherokee County, a small stream, Cherry Creek, is being contaminated from mine waters containing sulphuric acid. Interestingly, the polluting waters do not emanate from strip pits but from old shallow underground coal mines and a cave hole. Efforts are being made to stop the pollution by plugging the old mine shafts as the Kansas Forestry, Fish and Game Commission has promised the construction of a 4100-acre game refuge costing about $500,000 if the pollution can be stopped ("Action to End Pollution of Creek in Cherokee County Urged by Group," *Joplin News Herald*, July 22, 1959).

In Kansas, waters draining from the spoil banks or impounded in the form of lakes are not unusually toxic and therefore are not harmful to animal or plant life. This is indicated by the many strip pit lakes that are good fishing lakes and by the presence of fish in streams fed by waters draining off the spoil bank slopes. Furthermore, the growing of crops in areas adjacent to the Kansas spoil banks (figure 4) is sufficient proof that waters draining from the spoil banks have negligible effect in destroying or harming crops or other vegetation.

Hazards dangerous to life and property. That spoil banks may be hazards to life and property probably cannot be disputed. They are, however, in no way greater hazards than most natural areas. Also, it should be recognized that spoil bank lands are for the most part private lands, just as, for an example, are railroad right of ways. Persons entering such lands without permission are trespassers and do so at their own risk, especially if the land is posted or fenced. Certainly no trespassing person being caught on a railroad trestle by an approaching train is entitled to compensation from the railroad company for bodily injuries received because of risking his life on private property.

Health hazards—stagnant water. Unreclaimed spoil bank lands, some persons contend, create health hazards in that they afford places for the accumulation of stagnant ponds, which become breeding places for bacteria and mosquitoes, and other obnoxious insects. In the coal-mining region of southeastern Kansas, where the annual precipitation is 40 in. or more, stagnant water is at a minimum and presents no special or serious problem insofar as safeguarding the health of people is concerned. Witness for example the more than 101,000 farmyard ponds in Kansas that have come into existence since the drought years of the 1930's. The question might well be raised, are these thousands of small farmyard ponds any less stagnant than the ponds created by stripping? Interesting in this connection is the fact that both the Federal Government and the State have not only vigorously promoted the construction of farmyard ponds and urged farmers to build them but have actually paid the farmers for doing so, either in cash expenditures

or in reduction of taxes on the surrounding land for a specified period of years, or both.

In Illinois the State asserted that the various water areas among the strip ridges constituted a public health hazard in that they furnished breeding places for bacteria and noxious insects and thus constituted a menace to the public health. The Supreme Court of Illinois held, however, that the health menace complaint was inadequate in that the State did not produce evidence establishing the fact that the water areas were actually dangerous to the public health and that if the State was attempting to remedy the evil of mosquito and bacteria breeding ponds as a measure to protect health, the act should be directed against the evil that threatens to introduce sickness or disease. The Court stated, "The rights of property cannot be invaded under the guise of a regulation for the preservation of health when such is clearly not the object and purpose of the regulation" (Supreme Court of Illinois Opinion—Northern Illinois Coal Corp. et. al. vs. Robert M. Medill, Director of Mines and Minerals, Docket No. 29996, Agenda 44, January 1947, p. 4).

The court was also of the opinion that the reclamation act would not necessarily eliminate all ponds or lakes and thus do away with the health hazards generated by noxious insects, etc., in that grading the land to approximately its original contour would presumably require that if the land originally contained ponds or swamps, as for example in areas of glaciation, they too would have to be restored.

Floods. In Kansas, no claim has ever been advanced that spoil banks have caused floods or are regarded as flood hazards in the coal-mining region, either in the past or currently. Instead of causing floods it is more logical to assume that spoil bank lands prevent floods in that the numerous trenches, depressions, or low places interspersed among the ridges serve as catchment basins for water draining off the ridges and thus impound the waters rather than release them. Undisturbed spoil bank lands, because of their internal structure and porosity, are capable of absorbing much greater quantities of water than non-stripped areas of similar rock strata and thus release less run-off to streams or do so more gradually than do normal and less pervious unmined slopes.

Isolation of land. The claim has also been made that stripping of coal causes tracts of land to become inaccessible or isolated from adjacent land by the piling up of the spoil banks. No areas of any size of this kind exist in Kansas. Where such isolated tracts exist, they are most likely to be the property of the coal operator, who for some reason found the land unprofitable to mine, and if so, the tract under consideration should not be of any concern to others. It is very doubtful whether any large area has become isolated or inaccessible to the owner by being entirely surrounded by spoil banks and whether legally it would be possible to do so if objections were raised to that effect. Again, any area of considerable size becoming isolated or inaccessible due to strip mining would constitute an exception to the general rule and certainly should not be the basis for compulsory reclamation.

Fig. 4. A typical cultivated field adjacent to spoil banks in Kansas, suggests forcefully that spoil banks do not necessarily cause soil erosion on adjacent lands nor render them unfit for growing of crops

Water conservation. It is stated that reclaiming spoil bank areas favors the conservation of water by reducing the runoff on reforested or revegetated land, thereby aiding in keeping the underground water table high. If ungraded spoil banks did not support vegetation then the claim might possibly have some merit, as it is recognized that vegetation does retard runoff. Casual observation, however, establishes the fact that grading or leveling practices are not a prerequisite for the growth of weeds, grasses, shrubs, trees, and other types of vegetation. Studies published by the U. S. Forestry Service (Clark, F. B., 1954, "Forest Planting on Strip-Mined Lands in Kansas, Missouri, and Oklahoma," U. S. Forest Serv. Cent. States Forest Expt. Sta. Tech. Paper 141, p. 4) show that insofar as Kansas, Missouri, and Oklahoma are concerned, more acres in the spoil bank lands were covered by natural forests than by forests planted by man (table VII), indicating thus that undisturbed spoil banks even-

Table VII. Spoil banks forested naturally and by man in Kansas, Missouri, and Oklahoma

	Forest area, acres	
	Natural	Planted
Kansas	3,345	2,325
Missouri	2,521	191
Oklahoma	563	212
Total	6,429	2,728

Fig. 5. Spoil bank lakes, which are common in the strip mining area of Kansas would be destroyed by backfilling as required by some of the mandatory reclamation acts. In Kansas 52 percent of the out-of-state fishing licenses are sold in the six strip mining counties of the State

tually acquire a protective vegetative cover, which in turn will retard runoff and therefore reduce general erosion.

Provisions for various projects. Land reclamation advocates point out that reclamation of spoil banks provides land for game preserves or refuges and, in general, protection for birds, game, or wildlife, sites for housing developments, land and space for airplane runways, and sites for parks and recreational areas. Although reclaimed spoil banks may provide all the projects listed, the question arises why a private owner should at his own expense be forced against his will to do those things in which he has no interest. The precedent of the Supreme Court of Illinois (previously discussed) clearly answers that question.

Unreclaimed spoil banks or nature-reclaimed spoil banks provide protection for game, birds, and wildlife in general as well as do artificially reclaimed areas. Also, the same may be said for game preserves or refuges. All that is needed in the latter case are signs labeled "Game Preserve".

That reclaiming spoil banks provides land for housing developments and land and space for airplane runways has very little significance, certainly in Kansas. Theoretically the claim apparently is valid; practically or realistically, however, the claim is faulty. It should be remembered that spoil banks consist of a heterogenous mass of broken rock of various kinds and sizes all arranged without any orientation. Consequently, the reclaimed, leveled, or graded spoil bank structurally is a porous mass of rubble permitting easy access and free circulation of air and water, the two chief agents affecting the weathering or disentegration and decomposition of rock materials. Geologic processes are not going to stop because an area has been leveled, and hence for long periods of time subsurface changes in readjustment and reorientation of the rock material are to be expected. In short, reclaimed spoil banks as well as other graded dump piles or artificially filled places do not afford the best nor even a good base for permanent housing developments.

A second consideration against reclaiming spoil banks for housing sites is the matter of location. Should reclaimed spoil banks provide for more land for housing developments, the question arises who wants to live there and why, especially when more favorable locations are conveniently available elsewhere? What has been said for housing developments applies equally to airplane runways.

Table VIII. Numbers of years of farming required to net an income equal to the coal royalty value on 160 acres of southeastern Kansas strip coal land, where the coal seam is 24 in. thick. The table is based on average coal yield per acre and average price per bushel for 1950-1959

County	Wheat	Corn	Oats	Barley	Rye	Sorghums for grain	Soybeans
Bourbon	27	31	63	50	74	45	40
Cherokee	29	41	60	34	79	53	46
Crawford	27	37	64	51	72	46	46
Labette	38	38	61	51	51	51	44
Linn	26	31	39	33	42	39	37
Osage	22	34	61	46	62	40	34

In regard to providing sites for parks and recreational areas, reclaimed or partially reclaimed spoil bank areas can and do offer favorable possibilities. There are several partly to fully reclaimed spoil bank areas in Kansas that are devoted to parks, recreational and otherwise. If any recommendations are in order for the coal and lead and zinc mining areas of southeastern Kansas, which currently is in need of any new developments to insure its future economic importance, the writer certainly would suggest that more spoil bank areas should be acquired and developed for park and recreational sites. There are at least 350 fine spoil bank lakes in eastern Kansas, most of which offer many and widespread sites for such purposes as fishing, boating, water skiing, swimming, and camping, all of which attract people and revenue.

As an example, in 1959 the six Kansas coal-producing counties of Bourbon, Cherokee, Crawford, Labette, Linn, and Osage netted $93,524 or eight percent of the State's resident fishing license fees, $1756 or 11 percent of the non-resident 15-day fishing license fees, $8383 or 52 percent of the non-resident fishing license fees, and $10,700 or seven percent of the combination fishing license fees. Hunting license fees of these same counties included resident fees of $219,224 or six percent and non-resident fees of $2773 or 12 percent (Kansas Forestry, Fish and Game Commission, 17th Biennial Report for Fiscal Year Ending June 30, 1958, p. 63). These figures indicate clearly that the strip pit lakes not only are an important source of revenue to the State but also that the motels, restaurants, service stations, and sporting goods and sportswear stores of southeastern Kansas are direct beneficiaries of the strip pit lakes, many of which would be destroyed if mandatory reclamation involving grading were enforced.

The recommendation includes no implication that the owner of the spoil bank land, either a private individual or a coal company leasing coal land, should be required by law to convert his spoil bank area into a park or recreational area at his own expense. Rather, the exercise of eminent domain by a legal public governing body should be employed or the area developed by the owner voluntarily as a good and profitable business enterprise or else developed by others through purchase of the land from the owner. An excellent case of the latter is illustrated by the 3200-acre Wee-Ma-Tuk project of central Illinois, well described and illustrated in the December 1959 issue of *Mining Congress Journal*, pages 70–71. Southeastern Kansas might well prosper by such adventures.

Other Considerations

There are other considerations besides those thus far discussed that bear at least indirectly on the problem of mandatory reclamation.

Income to the land owner. It is easily demonstrable that coal mining is economically a greater asset to a community than is farming of the same land. It is here proposed that reclamation of spoil banks should not be required, if at all, until the income to a landowner and the revenue for taxation due to mining are balanced by like income and revenue derived from normal agricultural pursuits. This is based on the theory that only then is land use of the mined and unmined areas comparable economically. On the basis of income to the owners of the coal lands, spoil banks in Kansas could well remain unreclaimed or lie fallow for 22 to 79 years depending upon what crop is raised and in what county.

As an illustration, the following case may be cited. An owner of a 160-acre tract of unimproved agricultural land underlain by a two-ft seam of mineable coal within the

reach of the stripping shovel would receive on leasing his land $64,800 in royalties, at the rate of 15 cents per ton of recoverable or marketable coal. This income would not involve the owner with any expenses in mining the coal and would permit him to be free to engage in any enterprise augmenting his royalty income. On the other hand, if the same owner had refused to lease his tract to the coal operator and devoted it entirely to the raising of crops—wheat, corn, oats, barley, rye, sorghum for grain, or soybeans—then on the basis of the average yield per acre and average price per bushel for the 1950 decade, it would require 22 to 79 years (table VIII) to net the owner a sum equivalent to that received from coal royalties in a single year. Furthermore, this income would not only involve the expenses of the seed, and a heavy investment in farm machinery, but also the owner's time and labor. In terms of land use, the one year of stripping, therefore, would have to be matched by 22 to 79 years of farming in order for the two to be comparable or to be in balance. Translated into terms of land use, the strip land should be permitted to remain unreclaimed or left undisturbed for 22 to 79 years before reclamation is justifiable.

Revenue for taxation. In the final analysis, required reclamation is for the purpose of enhancing the value of the land for purposes of taxation. Rule out increased taxes to the state or county and most of the benefits claimed for reclamation lose much of their significance. In Kansas most of the agricultural land underlain by mineable stripping coal is assessed for purposes of taxation at $15.00 to $25.00 per acre. The same land after stripping, unreclaimed and unfenced, is assessed at $5.00 per acre; if reclaimed and fenced, at $10.00 per acre. The rate of taxation on assessed valuation is computed at $4.00 per $100.00. Although the spoil bank is assessed at a lower rate than unmined land in Kansas, revenue derived from spoil bank land to the local and state government is still greater, as most of the spoil land in the State is assessed by the largest coal operator for purposes of taxation at the rate of $200.00 per acre (instead of $5.00 or $10.00) during the first year of operation. This is equivalent to paying taxes in advance for 20 or 40 years, depending upon whether the area is reclaimed and fenced or unreclaimed and unfenced.

It is not the purpose of this report to discuss the private financial business of Kansas coal mining companies; nevertheless, it is no secret that the coal companies pay real estate, state and federal corporate, federal withholding and federal security taxes as well as annual unemployment insurance. In addition, the coal companies pay large sums in the form of royalties to land owners whose land is being stripped for coal and make a notable contribution to the economic status of the coal mining communities in the form of a sizable payroll. Considering the coal industry in all its facets and comparing it to the agricultural activities of the same area, it is provable that in Kansas it would take 200 to 250 years of farming to raise the amount of money contributed by the coal companies in a short span of time. The same is true in Indiana, according to the Indiana Coal Producers Association. Translated into terms of land use, reclamation should, therefore, not be required for at least 200 years after mining has ceased or until economically the mining and farming enterprises are again in equilibrium.

Time. It is an undeniable fact that nature will reclaim the spoil banks eventually if left unreclaimed by man. The soil and vegetative cover of the unmined coal area which are commonly taken for granted were originally not present anymore than they are on the recently upturned and shattered rocks of the strip lands. Soil first of all had to be formed by the normal process of weathering of the rocks before vegetation was able to get a foothold.

Inasmuch as reclamation is assured without the help of man, the question arises, is the motive for conservation of reclamation of the spoil banks for the needs and benefits of the immediate generation or are we concerned more with the needs of the future generations? If the answer is for the present generation, then the motive is more or less mercenary and selfish, whereas if the concern is for the future then time will make its contribution.

If the data in table VIII have any merit and may also be interpreted as meaning that the assumed 160-acre stripped tract, insofar as land use is concerned, has served the equivalent of 21 to 79 future years of crop growing and therefore may remain fallow for that period of time, then the time factor is an element in the consideration of mandatory reclamation. It is doubtful whether a spoil bank that remains unvegetated in that period of time will support vegetation if graded and seeded by man.

Competition. While fair competition is recognized as wholesome and advantageous to the general welfare of the public, unfair competition is not only objectionable but should not be tolerated. Coal is, has been, and may be mined by stripping on both sides of the Kansas-Missouri state line, the mines being separated only by the state-line road. The trade territory served by the Kansas and Missouri mines is the same, as is the seam of coal being stripped. It would not be fair competition to the Kansas coal operator if he were required to reclaim his abandoned spoil banks, thus increasing his mining cost and thereby assuring a consequently higher price to the public, if his Missouri competitor across the road approximately 100 ft distant were not subject to the same or similar mandatory reclamation act, thereby permitting him to sell coal at a lower price or, if at the same price, thereby gain a higher profit.

Geological asset. From the viewpoint of geologists spoil banks are a great asset in that they afford excellent opportunity to observe and study the character and sequence of rock strata otherwise hidden from view. Much of the detailed geology of southeastern Kansas where the country is relatively flat is known chiefly from exposures of the coal and rock units in the highwalls of the pits. If Kansas had a reclamation act requiring backfilling of the last open cut and concealing the face of the unmined coal in the highwall from one to three ft above its top as in the states where reclamation is required, much of the geology of southeastern Kansas would be unknown. A thorough knowledge of the various coal seams and associated strata is fundamental in studies pertaining not only to correlation of coal and rock units, future mining developments, and outlining and computing of coal reserves, but to many other geologic problems of economic importance.

Voluntary Reclamation in Kansas

Although Kansas has no mandatory reclamation act, considerable rehabilitation of stripped land (Foresman, Frank J., "Stripped Land Rehabilitation," *Coal Mine Modernization*, 1952, pp. 343–351) has been undertaken by the Pittsburg & Midway Coal Mining Co., the largest coal operator in the State. According to Foresman (p. 343), rehabilitation and farming activities have been carried on since 1938 on more than 17,000 acres of company-owned land, part of which is stripped, part of

which contains no workable coal, and part of which is to be mined in the future.

At first, reclamation consisted of reforestation, which in 1945 gave way to the present restoration of the spoil banks to pasture land. The company owns and operates a pure-bred Angus farm and recently has bought Holstein calves, which when bred are sold to southeastern Kansas farmers and others for the purpose of creating a dairy industry. Likewise, the pure-bred Angus cattle, after having been fed, are sold in the fall to interested buyers. Pittsburg & Midway's cattle enterprise is aimed primarily as a service to southeastern Kansas farmers in that the company deals only with good stock, assumes all the costs and risks in raising the cattle, and puts them on the market in the very best condition.

Also, many of the company-owned strip pit lakes have been made accessible to the general public for fishing and other purposes, and in periods of drought have yielded water to farmers as well as to communities. On a lesser scale, other coal mining companies have reclaimed some of their spoil banks.

Not only have the Kansas spoil banks been studied by various scientists* but state, county, city, and private clubs have converted some of the spoil bank areas into parks and recreational sites as well as into quail farms and the like. As part of the Civilian Conservation Corps program, 3400 acres of spoil bank land was graded during the period from 1933 to 1937 (Rogers, N. F., 1951, "Strip-Mined Lands of the Western Interior Coal Province," Mo. Agr. Expt. Sta. Res. Bull. 475, p. 16).

Objections to Mandatory Reclamation

As should be apparent from a reading of this article, it is not the intent to disclaim or discredit reclamation or rehabilitation of spoil banks per se. Rather, the criticism is directed towards mandatory, forced, regimented, or legislated reclamation. In the first place there is no real need for it. Many of the coal companies are practicing rehabilitation voluntarily and those that do not will have their spoil banks reclaimed by natural processes in due time.

In the second place, compulsory reclamation acts are not justifiable in that they interfere with man's constitutional right or freedom to engage in enterprises of his own choosing and in that they are unconstitutional, as states are without authority to demand a land use other than that favored by the owner himself, or even more so to compel a non-owner, a leaser of coal land, to reclaim someone else's land at his own expense.

Third, claims that spoil banks are the cause of many bad or injurious effects on the land or on man himself are unsubstantiated and certainly weak or flimsy at the best.

Fourth, man in America inherently resents regimentation or being told what he may or may not do and having to get permission from outside sources relative to what, when, and how he may operate his own land, or that belonging to someone else as in the case of a leaser of coal land.

Fifth, mandatory reclamation acts are discriminatory in that they do not apply equally to other analagous types of mining and are not even consistent in the coal mining industry itself.

Sixth, grading the surfaces of all spoil bank areas to a more or less rolling topography or one approaching the original contour of the land as currently required by all mandatory reclamation acts now in force is not warranted. Only if rehabilitation is for the purpose of growing row crops is leveling of the surface necessary, as reforestation and land use for pasturage and recreational purposes do not necessitate a graded landscape. Grading the spoil banks solely for esthetic reasons is not realistic. Furthermore, grading also tends to compact the materials composing the spoil banks, making them less pervious than when ungraded and therefore less productive and more affected by microclimate. Grading also is the most expensive item in the entire rehabilitation program, thus adding greatly to the cost of producing the coal. In Kansas it has been estimated that the cost of complete grading or leveling of the surface amounts to as much as $800.00 per acre, a prohibitive cost in comparison to the financial returns received on a two-ft seam of coal. Applying the lesser cost of $60.00 per acre applicable in Maryland and Pennsylvania for release of required reclamation, the cost to be released from reclaiming a 160-acre tract of spoil banks would be $9600, or $38,400 for a section of land, a sum still excessive for the Kansas coal operator to assume.

Seventh, the cost of required reclamation to the coal operator, including not only the actual cost of rehabilitation but also the additional annual payment to the state for the privilege of mining coal by the surface method but not required of other coal, metal, and nonmetal mining companies, plus the cost of rendering bond or depositing a specified sum of money as surety for reclamation purposes is an imposition levied on the coal operator.

Eighth, the nonparticipation of the conservation-minded Federal Government in a cost-sharing program relating to spoil bank conservation measures is discriminatory in that the Government pays 50 to 80 percent of the cost in conservation projects relating to normal agricultural land (table IX). It is not unreasonable to expect the Government to be interested and to participate in all types of conservation, reclamation, or rehabilitation whether the cause for the conservation is natural or man-made.

Table IX. List of conservation projects and percent of governmental cost-sharing to the farmer*

Conservation project	Percent of cost
Terraces—to detain or control flow of water and to check soil erosion	70
Planting trees to prevent wind and water erosion	80
Trees and shrubs	80
Diversion terraces	70
Erosion control dam	70
Outlet structures	60
Drainage ditches	50
Waterways—shaping	75
Waterways—seeding	75
Ponds	70
Pasture wells	50
Seeding pastures	80
Seedbed preparation—cost	80
Seeding rangeland	80
Spraying pastures—chemical treatment	50
Land leveling for irrigation	50
Impounding water for irrigation	50
Removing hedgerows	$1.00 per rod
Approved fence	$1.00 per rod
Agricultural lime	$1.50 per ton
Drilling grass seed	$0.90 per acre

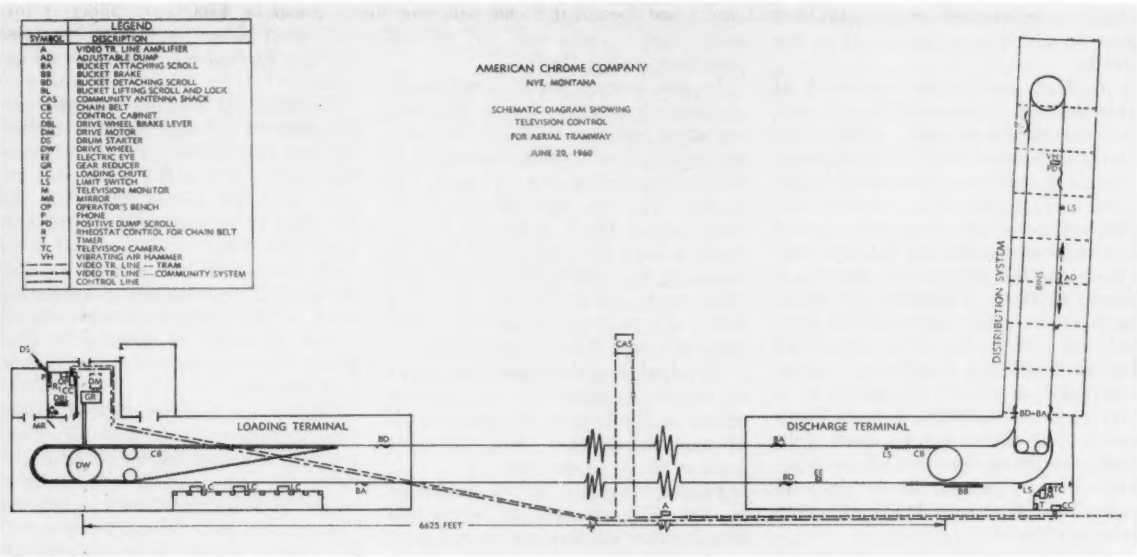
* *Wertzberger, M., "Terrace Aid Is 70 Percent," Lawrence, Kans.,* Daily Journal-World, *January 15, 1960, p. 14.*

Recommendations

In view of the everpresent threat to legislate for mandatory reclama-

(*Continued on page 78*)

* *Hall, H. H., 1940, "The Romance and Reclamation of the Coal Lands of Southeastern Kansas," Kans. Acad. Sci., Trans., Vol. 43, pp. 57–68, and 1943, "The Geological History of the Coal Lands of Southeastern Kansas," Kans. Acad. Sci., Trans., Vol. 46, pp. 179–184; Eshbaugh, F. P., "The Place of Research in Relation to Certain Phases of Stripland Reclamation in Kansas," Kans. Acad. Sci., Trans. Vol. 52, No. 2, 1949, pp. 117–260; Wells, J. R., "The Reclamation of Strip-Mined Areas in Southeastern Kansas," Kans. Acad. Sci., Trans. Vol. 56, No. 3, 1953, pp. 269–292.*



Automation of the Mouat mine aerial tramway

Efficiency and safety of the aerial tramway — a vital link between the mine and mill — have been greatly improved with installation of a closed circuit television system and automatic equipment

By GUY P. MORRIS
Mechanical & Electrical Superintendent
American Chrome Co.

OPERATIONS of American Chrome Co., which is a subsidiary of the Goldfield Consolidated Mines Co., are located at Nye, Mont., at the southern end of the Stillwater Valley, 45 miles from Columbus, the nearest rail point. According to Bureau of Mines findings, 80 per cent of the known reserves of chromite in North America occur in the Stillwater Complex with a major percentage of these reserves at the Mouat mine, which is under lease to American Chrome.

The existence of these deposits has been known for over 70 years. However, it was not until 1941, when it appeared that foreign chromite imports, through the vulnerable sea lanes, might be cut off due to enemy submarine action, that any extensive action was taken to open and develop them. At that time, the Defense Plants Corp. of the Government entered into a contract to mine and mill these chromite deposits. A complete mine and concentrating plant were provided together with extensive housing and roads. At the same time, the nearby Benbow and Gish properties were opened and equipped.

Less than 30,000 tons of chromite concentrate were produced from the Mouat mine, and although not of high quality, it would have been of much value had the emergency continued. The operation was closed by the Government in 1943 after it had been assured the sea lanes would remain open. All of the plant and equipment, save the concentrator, mine buildings and a few houses, were dismantled and sold.

Two Commercial Veins in Mouat Mine

In 1952, American Chrome contracted with the Defense Materials Procurement Agency to produce and stockpile 900,000 tons of chromite concentrate at a grade of 38 per cent or better Cr_2O_3 from the Mouat mine over a period of eight years.

Rehabilitation of the mine and concentrator and construction of 1¼ miles of aerial tramway and housing facilities was begun in 1952 and by August 1953 all of the plants were in operation on a limited tonnage. The break-in period lasted until February 1954 when the goal of milling 1000 tpd was achieved.

Although there are several bands of chromite in the Stillwater Complex, only a few are known to be of commercial value. Two of these, designated as the "G" and "H" veins, are found in the Mouat mine. These ore bodies parallel each other about 400 ft apart, dip from 50° to 75° northwest and strike from S 40° W to S 70° W. The bands of chromite occur as a series of overlapping lenses in the bronzitite and poikilitic harzburgite rocks of the ultramafic zone.

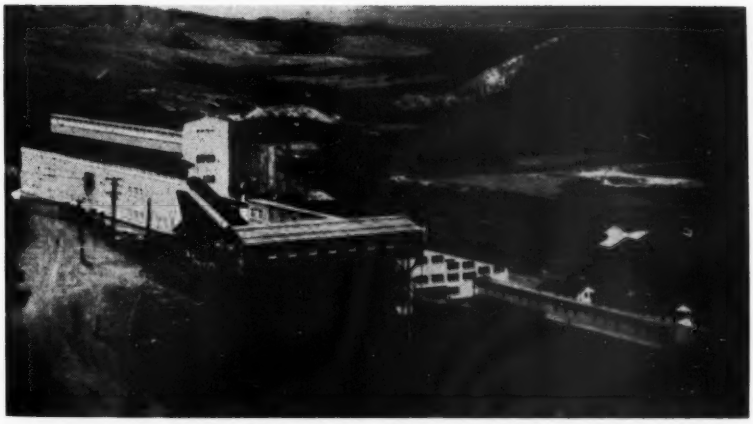
The "H" vein is composed of six in. to two ft of massive chromite on the footwall, while the "G" vein is composed of a few inches to eight ft of massive chromite on the footwall. The veins grade from the massive chromite into the hanging wall either as disseminated chromite or as smaller massive lenses between layers of waste. In order to determine the hanging wall, close assay control is required. Both hanging wall and footwall rocks are strong and stand well without support.

Shrinkage Stoping is Prevalent Mining Method

The mine proper is developed by five separate adits spaced at 150 ft vertical intervals and are known as No. 1, 2, 3, 4, and 5. The No. 5 level is the main haulage level and averages seven by eight ft in cross section.

Broken ore from the stopes is handled in 50 cu ft Granby type cars on the upper levels. Each vein on producing levels is serviced by a separate motor, which may be either a one or 3½-ton battery or a four-ton diesel motor. Ore is moved to a central transfer system and passed from level to level down to the main haulage level. At this horizon, it is loaded in 70 cu ft Granby type cars and hauled by either a four or six-ton diesel locomotive to the primary ore bin.

Shrinkage stoping has been the prevailing method used throughout the mine. Its choice was determined by the strong walls, steep dip and vein irregularities. However, other methods, such as open stopes, long-hole stoping, scraper loading or use of overshot loading, have been utilized wherever conditions indicated they would be more efficient. A systematic stoping retreat from the property endline and the top levels of the mine or fault lines has been employed.



Lower tramway terminal and concentrator with reduction plant in background (right)

An extensive diamond drilling program, recently completed, confirms the belief that the ore continues downward below the No. 5 level.

From the primary ore bins, the ore passes through the primary jaw crusher, where it is crushed to four in. and is transported by conveyor to the tramway bins. It is then transported 1¼ miles by aerial tramway from the mine to the mill and deposited in bins above the secondary crushing plant.

Ore is drawn from the secondary bins by means of a pan feeder and transported to a vibrating screen by conveyor belts. Screen undersize is minus ½ in.; oversize passes through a 4¼ ft cone crusher set to crush to ½ in.

Crushed and screened material is transported to the fine ore storage bins by conveyor belt. The tonnage of crushed material is recorded by a conveyor scale located just ahead of the fine ore storage bins.

Gravity Concentration Plant

From the fine ore storage bins the ore passes through 6 by 12 ft rod mills operating in closed circuit with hummer screens. Screen undersize goes to hydroseparators from which the overflow goes to a thickener while the underflow goes to hydraulic classifiers.

The classifiers in the gravity concentration plant, due to certain modifications by company personnel, are superior to any other classifiers used for feeding concentrating tables.

A total of seventy-two 14 by 7 ft tables used in the concentrator handle upwards of 900 tpd of ore. Half of the tables comprise the coarse section and receive feed from two hydraulic classifiers. The middlings section, which is comprised of 12 tables, receives middlings from the coarse tables after they have passed through a dewatering classifier and a hydraulic classifier.

The overflow from the hydroseparators and the original hydraulic classifiers passes to three thickeners. Thickener underflows are distributed to 24 tables which make up the fine table section.

Concentrates from all three table sections pass through two dewatering classifiers and are sampled as they pass onto a conveyor belt that delivers to one of three storage areas. From the storage areas, the concentrates are hauled, either to the Government stockpile or to the mix plant to be used as reduction plant feed.

Plant Facilities Being Expanded

From the outset of this operation, it has been the company's goal to establish an integrated chromite mining, milling and smelting operation. This would be the only reliable source of ferrochrome produced from domestic chromite ore available to the steel industry in time of peace as well as in the event of a national emergency.

After an extensive research and development program to determine feasibility of producing ferrochrome from the company's chromite concentrate, a ferrochrome plant was erected and operation started in December 1958.

The operator in the upper terminal control booth is stationed at the control console viewing the operations in the lower terminal on a television set in the other end of the booth. Warning horns and controls can be seen in background

Shipments have been made to leading steel producers who report the ferrochrome entirely satisfactory. As a result, it was decided that a second furnace be installed which would allow further refining and broadening of the product line.

At this time, the company is in the process of erecting an addition to the reduction plant and installing a nine ft, three phase, tilting furnace to be used for the refining operation.

It has been the conviction of management that one of the most important factors in establishing a reliable industry at this location is that every phase of the operation must be constantly observed, and efficiency and safety must be raised to the highest possible level. This has been the goal of the supervisory and operating personnel since the plant was started.

Tramway Automation Improved Efficiency

One example of improved efficiency is the automated aerial tramway, a development which resulted from observation of each phase of the system and thoughtful planning for the desired changes. An exchange of ideas with other operating systems and a policy of teamwork among those interested in the tramway have brought about gratifying results.

The accompanying line sketch (see figure 1) will be helpful in understanding the tramway design and the changes which have been made. The head end of the tramway is located at the mine at an elevation of 6816.5 ft and the discharge terminal is located at the mill at an altitude of 5125 ft; a vertical fall of 1691.5 ft over a slope distance of 6625 ft. The tramway is a bi-cable design installation with a capacity of 80 tph. The haul cable travels 550 fpm discharging a bucket in the terminal each 40.6 seconds.

All seven bins in the discharge terminal are arranged at right angles to the line of the tramway, therefore, the buckets must be removed from the main tramway and carried over the bins. The buckets are then returned to the main line to be carried back up to the loading terminal.

When the operation first began, it was necessary to have two men on duty on each of the two shifts in the discharge terminal. One man watched the incoming buckets and slowed them after they left the main tram so as to enter the distribution tram at the correct speed. A spring type brake on the tram proved inadequate for the job. The same man also controlled the dump bars for dumping into the proper bins.

When the muck contained a certain amount of moisture, it would hang up in the bucket making it necessary to finish dumping by hand. The second man received the empty buckets from the distribution tram and closed them. He then pushed them a distance of 50 ft, getting them moving nearly as fast as the haul cable before attachment to it.

Automatic Bucket Dump Installed

It was apparent that handling of the buckets in the discharge terminal could be simplified. The problems were tackled systematically in the order of importance.

First, it was important that a method of automatically emptying each bucket be found. By welding a two-in. by ½-in. pin at one end of the bottom of each bucket with six in. extending below the bucket and installing a spiral bar over the last bin, the forward motion of the bucket would roll it over causing it to completely dump. The next move was to install a second spiral bar which would catch the pin on the bottom of the bucket and automatically close the bucket.

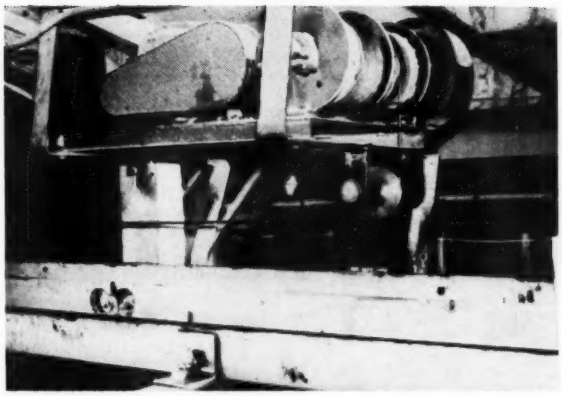
To eliminate manual pushing of the bucket, the final section of track on the distribution tram was elevated to allow the buckets, when released, to coast around to the main tram. A chain conveyor with dogs on it was installed so it would catch the buckets and roll them up another section of elevated track. The elevation of this section of track was established so the buckets would coast down the following slope and attain the same speed as the haul cable.

The next problem was to slow the incoming, loaded buckets so they would enter the distribution tramway at reduced speed. The use of a hydraulically operated brake solved this problem. As the buckets enter the discharge terminal, they are detached from the haul cable and coast along a rail about 60 ft long. A section of this rail was sloped upwards for two reasons; first, to slow the buckets somewhat before entering the brake and second, to allow the buckets to coast into the distribution tram at the correct speed after leaving the brake.

The hydraulic brake, placed just beyond the crest of the rail elevation, is operated by a four-way double solenoid valve which is, in turn, energized by two limit switches. One limit switch is located just inside the terminal where the bucket is detached from the haul cable. It energizes a time relay which, after a set number of seconds, energizes the solenoid that acts to open the brake.

As the loaded bucket enters the terminal, it trips the limit switch as it rolls up the incline and into the closed brake which stops, or nearly stops, the bucket. At the end of the predetermined time interval, the brake opens and the bucket rolls down the incline around a 90° curve and into the distribution tramway. Shortly after the bucket leaves the brake, it trips the second limit switch which energizes the opposite solenoid on the four-way valve, causing the brake to close in readiness for the next bucket.

At this point, it became evident that nearly every operation in the lower terminal had been automated except the positioning of the dump bars over the bins. The crew was reduced to one man per shift. The duties of this man were to observe the operation of the automatic equipment and provide dumping in the correct bins.



Drive mechanism for positioning movable dump bar. The cables pass over pulleys at each end of the row of bins and back to the dump bar which moves below the drive

Installation of Closed Circuit TV

After careful consideration, it was decided that the installation of a closed circuit television system would improve the operation since it would allow the operator at the loading terminal to see what was going on in the discharge terminal. This would reduce the possibility of expensive wrecks, since it would eliminate the time delay experienced when a man had to reach a telephone to sound a warning, and also eliminate the need of a man to observe the operations in the discharge terminal.

One remaining job in the lower terminal had to be mechanized. This was the positioning of the dump bars. Instead of having a dump bar for each bin, a movable bar was built which could be moved from bin to bin by means of a reversible motor and cable hook-up on the dump bar carriage.

A television camera was installed in a small room in the corner of the discharge terminal behind plate glass windows. The camera is equipped with a turret which holds three lenses —a standard, a wide angle and a telephoto lens. It is possible to pan the camera in a circle or to tilt it up or down. The signal generator was installed in the same room.

It was necessary to install an 18 wire control cable between the two terminals to give the operator at the loading terminal complete control over the discharge terminal. The control circuit is 24 volt d-c which makes it possible to use fairly small wires in the cable.

The television video signal is transmitted over a co-axial cable from the discharge terminal to the loading terminal. In order to provide adequate signal strength in the loading terminal, it was necessary to install an amplifier half-way up the line. This amplifier gives the channel 2 signal enough boost to provide a clear, sharp picture in the operator's booth.

Limit Switches "Guard" Tram System

From his control booth at the loading terminal, the operator turns on the lights in the discharge terminal, starts the distribution tram, the chain conveyor and the hydraulic pump for the brake. He can also turn on the power to the camera and signal generator and control the pan and tilt of the camera as well as change the lenses when necessary.

In order for the operator to know that all of the system is functioning correctly, several warning signals and indicating lights were installed. Connected to the limit switch, which opens the brake, is a small light which is located in view of the camera. When an incoming bucket trips the limit switch, the light turns on; the light stays on until the bucket trips the second limit switch as it leaves the brake. From this signal, the operator is assured the brake is cycling correctly.

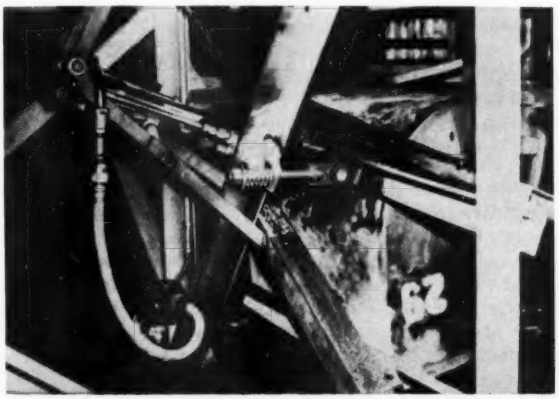
A limit switch, which is connected to a time delay relay, is located at the discharge end of the chain conveyor. When the tram is operating correctly, the time interval is 40 seconds between buckets. The time delay is set at 50 seconds so that if a bucket does not leave the terminal at the correct interval, the operator can shut down and then scan the terminal to determine the trouble.

In the event a bucket does not stay closed after leaving the closing spiral, a guard will stop the bucket and prevent it from going onto the main tram. The tram-way operator can then call the secondary crusher operator, who is on the floor below the terminal, and have him close the bucket and get it back in the circuit.

If a bucket on the loaded side of the main tramway should become hung up, the bull wheel, which is mounted on tracks and connected to a weight box, will move forward. A limit switch is placed about 12 in. in front of the bull wheel so that if it moves forward that distance, it will sound a warning to the operator and he can shut down and determine the cause for the warning.

Bucket Beater Loosens Muck

In the winter time, frozen muck in the buckets can be troublesome. It has been necessary to have men stand and beat on the buckets to break the muck loose. To alleviate this problem, a bucket beater was built out of a discarded jackhammer and mounted on the steel-work over bin No. 6. The bucket trips a limit switch which energizes a solenoid valve admitting air to the jackhammer. The limit switch is located so that it is held in the on position as long as the bucket is passing it. As soon as the bucket passes beyond the limit switch, it snaps off and, in turn, shuts off the air to the hammer. This arrangement takes care of about 75 percent of the frozen bucket problems. When condi-



Bucket passing in front of bucket beater as it goes along the finish dump spiral

tions are severe, it requires more hammering which must be done manually.

The installation of the television closed circuit system and automatic devices has resulted in a 50 percent reduction in operating labor. Formerly, eight men were required to tram an average of 899 tpd but today, four men are averaging 895 tpd.

While a small increase in maintenance cost might be expected, due to replacement of vacuum tubes and other replacements in the electronics equipment, the saving is appreciable. The total expenditure for automation equipment was approximately $8000. It is estimated the saving experienced will offset this cost in seven operating months.

A systematic plan of preventive maintenance and regular inspection of cable, buckets, towers, and terminals has resulted in an extremely efficient and safe tramway operation. In the seven years the tramway has been in service, there have been few wrecks and none of them could be classed as major. Also, up to June 21, 1960, a record of 2323 days without a lost-time accident has been established by this department.

Other operations in the plants are being observed and studied and wherever possible, automation will be employed to improve the overall efficiency.

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LAND RECLAMATION

(*Continued from page 73*)

tion and the more recent probability of national interference, it behooves the coal industry to study thoroughly its spoil bank problem, which is real, and to be prepared to meet and defend against any attack made by those favoring mandatory reclamation.

A second recommendation offered is that coal operators wherever possible practice some sort of reclamation most desirable from the coal operator's viewpoint and one without any directives or strings attached from outside sources. Such practices tend to weaken materially any claims made by proponents of mandatory reclamation.

Agitate for and request governmental cost-sharing participation in all reclamation or rehabilitation projects of spoil banks. Within the last decade or so the Federal Government has spent millions of dollars payable to farmers for aid in conservation projects of various types or forms. The extent to which farmers are aided by the Federal Government is indicated by table IX, which lists the cost-sharing percent participation by the Government. If the Government is interested in conservation to the extent of paying farmers 50 to 80 percent of the cost of putting into effect conservation measures, then it is not unreasonable nor illogical to expect similar governmental participation in reclaiming spoil banks.

If conservation is the goal, it matters little as to how the land became in need of conservation measures. It should not and must not be assumed, for example, that every farm in the conservation program is in need of conservation measures because the cause was a natural one. Misuse of the land resulting in gullying and general erosion of the land, soil loss, depletion of food ingredients in the soil, etc., may well be attributed to man's neglect and carelessness, unwise removal of the original vegetative cover, overcultivation, overgrazing, deforestation, and general unwise use of the land. Yet, the Government will aid the farmer to regain this type of land. The question naturally arises then why should the Government discriminate by not rendering financial aid to the coal operator whose spoil banks are the legitimate end-products of a worthwhile, useful, economic enterprise and not the product of man's carelessness and unwise use of the land? In short, the coal operators are entitled to the same financial aid as received by the farmers if the land is to be reclaimed and conservation is to be practiced by edict or on a voluntary basis. It is true, however, that governmental financial aid will not be forthcoming unless vigorously agitated for by the coal industry.

Before voluntary reclamation or rehabilitation is considered, planned, and started it would be advantageous to the coal companies to seek the advice and avail themselves of the services of all state and federal governmental agencies engaged in conservation, reclamation, or rehabilitation projects. Special reference is made to the excellent work of the Forest Service of the U. S. Department of Agriculture in forestation of strip-mined land and to the various state agricultural universities and colleges who are ever studying and experimenting on best methods of farming and general land use.

Bethlehem roof bolts clamp rock strata together to improve the safety in this coal mine.

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ANNUAL AMC COAL

November 17-18, 1960

RADIOISOTOPES IN THE COAL INDUSTRY

THURSDAY—NOVEMBER 17

The American Mining Congress and Bituminous Coal Research, Inc., are sponsoring this one-day conference in cooperation with the Atomic Energy Commission to point out how radiosiotopes can be used to advantage by the coal industry—mine operator and equipment manufacturer alike. Speakers will describe operations where this new tool is being used and will discuss potential areas of application.

Terrace Room, Penn-Sheraton Hotel

9:30 A.M.—PRESENT RADIOISOTOPES USE BY COAL INDUSTRY

Chairman: Jesse F. Core, Vice President-Operations-Coal, U. S. Steel Corporation, and Chairman, AMC Coal Division

Co-Chairman: J. R. Garvey, Vice President and Director, Bituminous Coal Research, Inc.

BCR REPORT ON RADIOISOTOPES—A survey of coal mining practice in this country and abroad has turned up many existing uses of radioisotopes. The paper will be based on this survey.

J. R. Garvey, Bituminous Coal Research, Inc.

RADIOISOTOPES, PROFITABLE NEW TOOLS FOR INDUSTRY—What is a radioisotope, what does it do and is it safe to work with? These are the questions that will be discussed by the author.

Paul C. Aebersold, Director, Office of Isotope Development, Atomic Energy Commission

CONTROLS IN COAL PREPARATION PLANTS—Radioisotopes have had their greatest acceptance by the coal industry of the United States in coal preparation equipment controls. Their application in the washing of bituminous coal and anthracite will be covered.

Charles O. Badgett, Chemical Industrial Manager, Industrial Nucleonics Corp.

RADIOGRAPHY IN PREVENTIVE AND ROUTINE MAINTENANCE—With radioisotopes it is possible to x-ray castings, forgings, weldments, etc. Some coal companies have turned to this technique to solve maintenance problems. Equipment manufacturers are using it as an aid in quality control and inspection.

A. J. Stevens, President, Radionics, Inc.

1:45 P.M.—POTENTIAL RADIOISOTOPE USE BY COAL INDUSTRY

Chairman: D. L. McElroy, Executive Vice President, Consolidation Coal Co.

Co-Chairman: A. E. Seep, President, Mine and Smelter Supply Co., and Chairman, AMC Manufacturers Division

MASS FLOW MEASUREMENT OF COAL IN MOTION—Where there is bulk flow of materials, radioisotopes are able to measure this flow. Here may be a potential coal industry application.

Philip E. Ohmart, President, The Ohmart Corp.

DENSITY/MOISTURE GAUGES IN THE COAL INDUSTRY—Automatic moisture and density determinations are now possible with instruments using radioisotopes.

O. K. Neville, Vice-President, Nuclear-Chicago Corp.

HOW TO GET STARTED IN THE USE OF RADIOISOTOPES—The Atomic Energy Commission has prepared a program for the guidance of companies interested in using radioisotopes.

P. C. Blaetus, Chief, Isotope Technology Branch, Office of Isotope Development, Atomic Energy Commission

CONFERENCE ROUNDUP—Actual and potential uses of radioisotopes in the coal mining industry will be recapitulated.

Harold J. Rose, Consultant, Pittsburgh, Pa.

DIVISION CONFERENCE

Pittsburgh, Pa.

REPORTS OF THE COAL DIVISION COMMITTEES

FRIDAY—NOVEMBER 18

Each of the seven Coal Division Committees will recount the results of work carried on during the past year. As in the past, the reports will be open to discussion from the floor so that all interested parties may have an opportunity to offer comments or suggestions.

Morning Session

9:45 A.M.—URBAN ROOM, PENN-SHERATON HOTEL

Committee on Roof Action—L. D. Ellison, Chairman

ROTARY PERCUSSION DRILLING—A review of operating experience with rotary percussion drilling.

THE COST OF POOR ROOF—What is the best way to determine how much can be spent for roof control?

Committee on Strip Mining—E. R. Phelps, Chairman

PERFORMANCE OF LARGE STRIPPING EQUIPMENT—A survey has been made of the strip mining industry to compare the performance of large stripping units.

Committee on Coal Preparation—J. J. Reilly, Chairman

FROTH FLOTATION—How large and small coal producers are using froth flotation.

THERMAL DRYING—A discussion of thermal drying practice at several coal preparation plants.

Committee on Mine Safety—W. G. Talman, Chairman

FIRE-RESISTANT HYDRAULIC FLUIDS—Progress in the development and use of fire-resistant hydraulic fluids will be discussed.

12:15 P.M.—BALLROOM, PENN-SHERATON HOTEL

ANNUAL COAL DIVISION LUNCHEON

Address

THE OFFICE OF COAL RESEARCH

Hon. Royce A. Hardy, Assistant Secretary, Department of the Interior

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Afternoon Session

2:00 P.M.—URBAN ROOM, PENN-SHERATON HOTEL

Committee on Mine Power—James A. Erskine, Chairman

IMPROVING TRAILING CABLE PERFORMANCE—A progress report on the Power Committee's study of trailing cable failures.

TRAINING A-C EQUIPMENT MAINTENANCE PERSONNEL—Designed to assist a company introducing A-C mining equipment, this study will cover various methods of training maintenance personnel.

Committee on Mechanical Mining—James A. Younkins, Chairman

VENTILATION WITH CONTINUOUS MINING MACHINES—An outline of present practice in ventilating continuous mining sections to dilute methane. Dust control will also be discussed.

APTITUDE AND ACHIEVEMENT TESTING—Five companies are cooperating in the evaluation of three types of aptitude tests to determine if continuous mining machine operator performance can be predicted.

Committee on Mine Haulage—A. G. Gossard, Chairman

TRENDS IN BELT HAULAGE—A review of recent developments in conveyor haulage.

TRENDS IN RAIL HAULAGE—A review of recent developments in rail haulage.

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As Viewed by HENRY I. DWORSHAK of the American Mining Congress

WITH the general election less than one month away, the air in the Nation's capital is surcharged with talk of politics. Washington's biggest business is government, and it is only natural that there is much speculation as to which party will be at the country's helm during the next four years.

There is much personal interest, too, for thousands of jobs in the Executive Branch are not, for various reasons, under Civil Service and will be filled by adherents of the victorious Presidential candidate. These range from Cabinet posts down to secretaries of lesser officials whose work may be connected with some phase of policy-making deemed beyond the purview of administrative career employees.

The Interior Department has not yet filled the newly created post of Director of the Office of Coal Research, but an announcement is expected within the next few weeks.

NO NEED FOR LEAD-ZINC QUOTA CHANGE SEEN

Conditions in the domestic lead-zinc mining industry have not changed enough to warrant a formal study which could lead to a recession of the quotas imposed October 1, 1958, on imports of lead and zinc, the U. S. Tariff Commission has advised President Eisenhower.

The annual quotas, which are equal to 80 percent of the average annual imports during the five-year period 1953–1957, were proclaimed by the President following an escape-clause investigation conducted by the Commission at the domestic industry's request.

This was the Commission's first report with respect to the quotas; its next report is due a year from now.

According to the report, U. S. mine output of lead declined from 338,000 tons in 1957 to 256,000 tons in 1959, lowest on record since 1899. Output in the first half of 1960, it noted, was only 3 percent more than in the first six months of last year.

★ ★ ★ ★ ★ ★

Washington Highlights

LEAD-ZINC: No need seen for import quota change

WATER POLLUTION: Court test of Federal law slated

NATURAL GAS: Examiner rejects importation proposal

SAFETY: Mineral industries set new record

TARIFFS: Reclassification report to be released

GREAT LAKES BASIN: Interstate water study set

★ ★ ★ ★ ★ ★

U. S. mine output of zinc declined from 532,000 tons in 1957 to 425,000 tons in 1959, lowest since the early 1930's, the report said. Output during the first half of 1960 was about 7 percent higher than in the corresponding period of 1959, it added.

Employment in the domestic lead-zinc mining industry declined even more sharply than mine output, the Commission reported. The total number of employees dropped from an average of 15,900 during the first nine months of 1957 to 9,800 during the corresponding period in 1959, the Commission said, and it estimated a further drop of 3 percent in the first six months of this year.

Shortly before the Tariff Commission submitted its report to the President, the 23-nation United Nations Lead and Zinc Study Group announced that there would be a surplus of lead and zinc during 1961 but urged member countries not to impose "new or additional barriers to international trade" in the two metals.

The announcement followed a meeting of the Group at Geneva, Switzerland. The United States participates in the Group's work.

In a review of the lead situation, the Group said that in 1961 both metal production and consumption are expected to rise at about the same rate and forecast a "statistical" surplus of lead metal of 21,000 metric tons for 1960 and 26,000 tons for 1961.

As to zinc, the Group said recent years have been characterized by steadily rising world production and consumption. Its estimated statistics show a surplus of 74,000 metric tons for 1960 and 102,000 tons for 1961. The Group pointed out, however, that "the indicated consumption [of zinc] may be about 50,000 tons too low in both years." Moreover, it added, "the rise in metal production will depend to some extent on the successful initial operation of several new plants and on the expansion of existing capacity."

COURT TEST OF WATER POLLUTION LAW SLATED

The Federal Water Pollution Control Act, as amended in 1956, established a procedure whereby the Government, acting through the courts, may enforce abatement of water pollution affecting interstate waters. In the first court test of the Act's enforcement provisions, the Department of Justice recently filed suit against the city of St. Joseph, Mo., to compel it to abate its pollution of the Missouri River.

Below St. Joseph the Missouri River forms the boundary between Missouri and Kansas, making this section of the river interstate waters as defined by the Act. Pollution of these waters, the suit asserted, "endangers the health and welfare of persons in the State of Kansas and constitutes a public nuisance in violation of the laws of Missouri."

Filed at the request of the Secre-

tary of Health, Education and Welfare, the Kansas State Board of Health, and the Missouri State Water Pollution Board, the suit stems from a 1957 meeting at which the U. S. Surgeon General recommended that steps be taken to abate the pollution. Over the next three years, according to the complaint, attempts were made in accordance with provisions of the Water Pollution Control Act to induce the city to set up an abatement program but "without success."

NATURAL GAS IMPORTATION PROPOSAL IS DISMISSED

A Federal Power Commission examiner has filed a decision dismissing an application by Tennessee Gas Transmission Co. which proposed the importation of natural gas from Canada on an interruptible basis.

The company had proposed to take up to 204 million cubic feet of gas daily, on an as-if-and-when-available basis, from Trans-Canada Pipe Lines, Ltd. Trans-Canada would have delivered the gas to Tennessee Gas at a point on the international boundary near Niagara Falls, N. Y., where the two companies have a pipeline connection.

The examiner said the Tennessee Gas application was dismissed because the company failed to show a market for the gas proposed to be imported, had failed to show the proposed price to be paid for the gas to be imported is in the public interest, and had failed to present a gas purchase contract.

His decision is subject to review by the Federal Power Commission.

MINERAL INDUSTRIES SET NEW SAFETY RECORD

A new work safety record was set in 1959 by the 1.1 million workers in the Nation's mineral industries, the U. S. Bureau of Mines has announced. Fatal injuries, which the Bureau said include some cases of total disability, declined 10 percent from 30 per 100 million man-hours in 1958 to 27 in 1959.

Total injuries, including fatal and nonfatal, declined to 17.51 per million man-hours of exposure, a reduction of 4.7 percent from the 1958 rate of 18.38.

According to the Bureau, the major factor in the new safety record was the continued safety gain in the industries employing the largest numbers. These include petroleum and natural gas, with nearly 600,000 employees; coal, with over 200,000; stone quarrying, metal mining, and metallurgical plants.

Among the major mineral industries, the Bureau added, cement and coke had the lowest accident frequencies, 4.67 and 4.87 respectively per million man-hours; coal mining had the highest rate, but scored a 2.1 percent improvement from 45.06 to 44.09.

TARIFF RECLASSIFICATION REPORT TO BE RELEASED

The Tariff Commission announced recently that it will make public on November 15 its report on a three-and-one-half year job of overhauling the rate schedules contained in the Tariff Act of 1930. The revamping was ordered by Congress in 1954.

In simplifying the Tariff Act's schedules, the Commission reduced them from 15 to nine but kept rate changes to a minimum in accordance with Congressional desires. Present classifications are a hodgepodge in which products turn up in unexpected places; under the revision, a product will appear within the classification that common sense would anticipate.

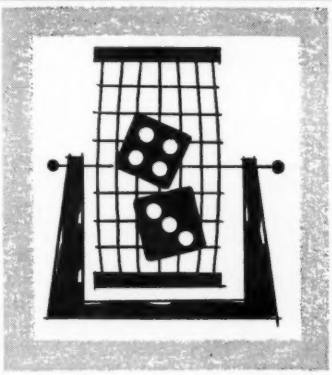
The Commission's report will be submitted to the President and Congress for further study. Congress must enact a law incorporating the new schedules before they can become effective.

MIDWEST WATER POLLUTION STUDY IS ANNOUNCED

A six-year study of pollution of waters under Federal jurisdiction in the Great Lakes Basin-Illinois Waterway has been inaugurated by the U. S. Public Health Service. Congress recently appropriated $500,000 to initiate the study, which will be made by the agency's Division of Water Supply and Pollution Control.

Surgeon General Leroy E. Burney said the study will direct immediate attention to (1) measurement and analysis of municipal and industrial wastes being discharged at all points of inflow into the Chicago River, Sanitary and Ship Canal, the Calumet-Sag Canal, and their tributaries; (2) effect of such discharges on water quality of the Illinois Waterway under present and various decreased rates of flow; and (3) methods of improving water quality of the Waterway.

The $560,000 appropriation covers only the first year of the project, a staff for which is now being assembled.



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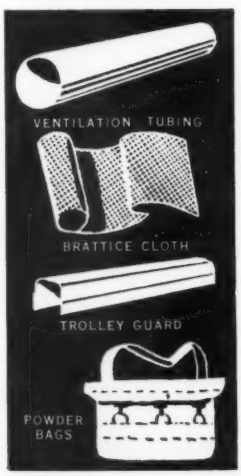

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personals

Arnold E. Lamm has been elected president of the Pittsburg & Midway Coal Mining Co., a subsidiary of Spencer Chemical Co. of Kansas City. Lamm, formerly president and a principal owner of the Sunnyhill Coal Co., has been named to fill the vacancy created by the resignation of **Edwin R. Phelps.** Lamm began his coal career in 1936 as a comptroller for the United Electric Coal Cos. of Chicago. Later he was elected secretary-treasurer. He went with Sunnyhill in 1946.

A. E. Lamm

Thomas R. Vaughn has been elected vice president and general counsel and **John C. Carrington** vice president of sales, Freeport Sulphur Co. Vaughn, who has been connected with Freeport's legal department for 18 years, became vice president in 1950 and general counsel for the company's nickel activities in 1956. Carrington joined the company in 1939 and since 1952 has been vice president.

T. R. Vaughn

J. C. Carrington

New directors recently elected to the board of directors of Consolidation Coal Co. are **Birny Mason, Jr.,** president of Union Carbide Corp., and **John A. Mayer,** president, Mellon National Bank & Trust Co.

Lloyd E. Elkins has been nominated president-elect of the American Institute of Mining, Metallurgical & Petroleum Engineers. Elkins, who is research production director of Pan American Petroleum Corp., will take office as president of AIME in 1962.

Several personnel changes in the Lynch, Ky., district coal mines of United States Steel Corp. include naming **Edgar B. Jenkins** to succeed **Robert Jordon** as mine superintendent of No. 32 mine. Jordon is retiring. Jenkins, who had been superintendent at No. 31 mine, has been succeeded in that post by **James O. Felton. Robert Wilt, Jr.,** moves into the position of maintenance superintendent which Felton had previously held.

Harry F. Magnuson and **William H. Love** were recently elected to the board of directors of Hecla Mining Co. Magnuson is vice president of Lucky Friday Silver-Lead Mines Co. and Golconda Lead Mines, while Love is general manager of Hecla and Lucky Friday and a director of the latter company.

Carl A. Peterson has resigned as vice president and general manager of Northwestern Mining & Exchange Co. to enter private consulting work in Brockway, Pa.

Hubert E. Risser has been appointed principal mineral economist of the Illinois State Geological Survey succeeding **Walter H. Voskuil,** who is retiring. Before joining the Illinois Survey in 1957, Risser served as a mining engineer and mining consultant to the Kansas Geological Survey in addition to duties as assistant professor of mining engineering at Kansas University from 1950. Earlier he had been mine superintendent at Alabama By-Products Corp.

H. E. Risser

G. H. Bryant, mill superintendent for Susquehanna-Western, Inc., at Riverton, Wyo., has been named manager of the company's metallurgical division in Denver. Bryant has been succeeded as mill superintendent by **Richard E. Shreve,** who was formerly mill superintendent for Gunnison Mining Co.

Daniel W. Machon has been appointed manager, Santiago Division, Chile, of Cerro de Pasco Corp. Machon, who most recently was in charge of administration for Freeport Sulphur Co. in Cuba, will have similar responsibilities for Cerro in Chile. He was previously connected with International Nickel as its general representative at various foreign posts.

Walter S. Benosky, mine foreman for the Morrisdale Coal Mining Co. at Clymer, Pa., for the past ten years has joined the U. S. Bureau of Mines at Johnstown, Pa.

Emmett W. Waltman, assistant manager of plant services division of the Bunker Hill Co., has retired after 44 years of continuous service.

John P. Lacke has been appointed resident manager of the Vinegar Hill Division operations of American Zinc, Lead & Smelting Co. in southern Wisconsin. He had previously been general superintendent and has served at these operations since 1916. The company also announced that **Paul F. Mills** has been promoted from assistant superintendent to mine superintendent.

Robert W. Taber has been appointed assistant to the president of the Cleveland-Cliffs Iron Co. He has been with Cliffs continuously since 1946 in various capacities in the sales, mining and finance departments.

Hal D. Webb recently became manager of the uranium ore processing and vanadium recovery plant of Mines Development, Inc., at Edgemont, S. D.

M. E. Johnson and **N. G. Helland** have been appointed managers of operations in charge of mines and plants in the Oliver Iron Mining Division, U. S. Steel Corp. Prior to the promotions, Johnson was assistant general superintendent of the western district and Helland was district superintendent in the Hibbing-Chisholm area. Other advancements include naming **M. R. Sermon** and **R. R. Wallace** as superintendent and assistant superintendent of mining engineering, respectively, for Minnesota operations.

Lawrence Litchfield, Jr., formerly executive vice president, Aluminum Co. of America, has been elected president succeeding **Frank L. Magee,** who was named chairman of the board.

L. Litchfield, Jr.

Litchfield joined Alcoa in 1925 as a geologist and has since had wide experience with the company and its subsidiaries in the mining, exploration and raw materials fields. He became vice president of the mining division in 1956 and executive vice president with responsibility for Alcoa's four operating divisions, as well as its engineering, purchasing and traffic activities, in 1959.

Frank W. Earnest, Jr., has resigned as president of the Anthracite Institute, Inc., a position he had held since the merger of Anthracite Industries and the Anthracite Institute in 1946. **John D. Jillson,** vice president of the Anthracite Institute, succeeds Earnest, who has become executive vice president of the Greater Wilkes-Barre (Pa.) Chamber of Commerce.

John R. Kringel has been named executive vice president of New York Trap Rock Corp. and has been succeeded as vice president, production, by **Henry Schwellenbach.** Kringel joined the company as plant superintendent at its Haverstraw quarry in 1954 and successively became assistant to the vice president, production; assistant vice president; and vice president, production. Schwellenbach was formerly production manager, and before joining Trap Rock, he had served in various capacities with copper, iron, gold and titanium mining companies in the U. S. and Chile.

J. R. Kringel

John R. Englehorn, formerly manager of the metal and ore department of the American Zinc, Lead & Smelting Co., has joined the executive office staff of St. Joseph Lead Co., where his duties will include raw materials procurement, metal sales, new product evaluation and related activities.

Walter Robertson was recently named vice president of operations for Harmon Creek Coal Corp. Robertson, who has been with Harmon Creek for 34 years, was previously mine superintendent.

H. Turner Loehr has become director of engineering, International Minerals & Chemical Corp. He had previously been in the company's phosphate mining division at Bartow, Fla.

J. M. Vonfeld has been appointed manager - exploration, Consolidation Coal Co. He had previously been product control manager of Pittsburgh Coal Co.

George McCaa has been promoted from manager of the Ireland mine to general manager of underground mines for Hanna Coal Co., Division of Consolidation Coal Co. McCaa has been with Consol since 1946, when he became superintendent of Mine 25. Earlier he had worked for several coal companies in Pennsylvania, Alabama, Tennessee and West Virginia.

His career began in 1935 with the Pittsburgh Coal Co. Other changes in the Hanna organization include naming **Tom Durbin** general manager of surface operations, and **Clyde Gibson** general superintendent of underground mines. Before promotion, Durbin was general superintendent of the Georgetown Preparation plant and Pipeline Division, and Gibson was general superintendent of Ohio underground mines.

H. I. Altshuler, vice president of New York & Honduras Rosario Mining Co., has become an associate member of Behre Dolbear & Co., New York, mining, geological and metallurgical consultants. Altshuler, a mining engineer whose career spans 42 years, has done professional work in the United States. India and various Latin American countries.

OBITUARIES

S. Livingston Mather, 78, retired vice president of operations, Cleveland-Cliffs Iron Co., died at his home near Mentor, Ohio, on September 11.

Mr. Mather joined the Cliffs Corp. in 1905 at its iron ore mining operations in Michigan and three years later was transferred to the company's Cleveland offices. He subsequently became assistant secretary, secretary and in 1926 vice president. When Cliffs merged with Cleveland-Cliffs Iron Co. in 1946 he was vice president-operations, the position he held when he retired in 1947.

Mr. Mather was president of the American Mining Congress from 1930 to 1932 and a former director. He was also a former director of the Lake Superior Iron Ore Association.

H. K. Ihrig, vice president in charge of research, Allis-Chalmers Manufacturing Co., died in Shorewood, Wis., on August 22.

Dr. Ihrig, an inventor as well as a researcher, held 22 United States patents. He was awarded the Robert L. Hunt medal of the American Institute of Mining & Metallurgical Engineers in 1947 and was cited by the University of Wisconsin, College of Engineering, in 1949 for important contributions and inventions in the field of metallurgy.

Eric Mitchell, 60, vice president of the Pennsylvania Coal & Coke Division, Fairbanks Whitney Corp., died in New York City on September 5.

Mr. Mitchell was vice president of operations for Simpson Creek Collieries Co. until 1951 when he joined Fairbanks Whitney.

Frederick Burbidge, 96, former general manager of Federal Mining & Smelting Co. and an early day general manager of the now Bunker Hill Co., died in Spokane, Wash., on September 11.

Mr. Burbidge's 48-year career in the mining industry began in 1882 with Orford Nickel & Copper Co. He was general manager at the Bunker Hill in 1899 during the tragic Coeur d'Alene riots and later became manager of Federal Mining & Smelting Co He retired from the latter position in 1930.

Paul Hett, retired assistant general manager of the Nevada Mines Division of Kennecott Copper Corp., died July 31 in Ogden, Utah.

Mr. Hett was employed for 32 years by Kennecott's Nevada Mines Division and its predecessor company in White Pine County, Nev., until he retired in 1955 because of ill health.

NEWS and views

Georgia-Pacific and Ritter Plan to Merge

Georgia-Pacific Corp. recently announced that an agreement has been signed whereby W. M. Ritter Lumber Co., owners of timber and timberlands, natural gas, and metallurgical coal reserves, is to be merged into Georgia-Pacific. The merger is subject to stockholders approval. Included in the W. M. Ritter holdings are proven metallurgical coal deposits of over 350,000,000 tons as well as substantial unproven deposits, principally in West Virginia and Virginia. At one time the Ritter interests operated coal mines in West Virginia and Kentucky under the corporate name of Red Jacket Coal Co. These properties were sold to Island Creek Coal Co. in the early 1950's. Georgia-Pacific is a large integrated producer of forest products including plywood, pulp and paper, containerboard, lumber and chemicals.

Direct Iron Ore Reduction Plant to be Built in Ontario

New Mylamaque Explorations, Ltd., has contracted with Koppers of Canada, Ltd., a subsidiary of Koppers, Co., Inc., and Strategic Materials Corp. for the construction of a smelting plant on Lake Ontario near Kingston, Ontario, for the production of pig iron by the Strategic-Udy Direct Reduction Process. The contract also calls for technical and operational management of the smelter by Koppers Co., Inc.

Additionally, a concentrating plant will be built, and facilities will be provided to utilize New Mylamaque's iron ore property at Newboro, 35 miles north of Kingston. Limestone will be obtained from an existing deposit at the smelter site. Total cost of the entire project is estimated at $14,000,000 and construction is scheduled to begin early in 1961.

The smelter, which is expected to begin operations in the first half of 1962, will have an estimated production capacity of 150,000 net tons of pig iron per year.

TVA Coal Use Increases

Tennessee Valley Authority purchased nearly 18,900,000 tons of coal during the fiscal year ending June 30 and used all but about 333,000 tons at its steam plants. Bulk of the coal received at the plants last year came from western Kentucky, Tennessee, and Illinois. TVA expects to burn 20,000,000 tons during the current fiscal year and estimates it will burn about 40,000,000 tons per year in about ten years.

Humboldt Mine Opens Pellet Plant

On September 16 Humboldt mine opened a 650,000-ton per year pelletizing plant to produce high grade iron ore pellets from Michigan's comparatively low grade jasper rock. Humboldt Mining Co., pioneer producer of jasper concentrates in the Upper Peninsula of Michigan, is owned jointly by the Cleveland-Cliffs Iron Co. and Ford Motor Co.

The iron-bearing mineral found in jasper is hematite which is non-magnetic and not amenable to magnetic separation as are the magnetic taconites of Minnesota. Instead, the Humboldt ores will be treated in a flotation plant. The concentrate is then processed into balls which are fed onto a traveling grate machine for drying and initial hardening. The pellets are heated to a temperature of 2450°F in a large rotary kiln, 16 ft in diameter and 120 ft long, for final hardening into firm, durable balls.

At the opening ceremonies, Walter A. Sterling, Cliffs' chairman and chief executive officer, commented that "This development of a high iron content ore from the vast low grade reserves of the Lake Superior region, which is in strong demand by the steel industry, offers the prospects of economic rebirth for the area. This is an attempt to answer the competition of rapidly increasing importation of high-quality, low-cost ores from overseas which have made former standard grade ores unsalable."

Metal & Thermit Acquires Zircon Company

Metal & Thermit Corp. has expanded its activities in the minerals field with the acquisition of the resources and facilities of Orefraction Minerals, Inc.

The 44-year-old Orefraction Minerals, with facilities in Andrews, S. C., supplies granular and dry milled zircon for the foundry, refractory, ceramic and glass industries.

Metal & Thermit, which has diversified interests in chemicals, metals, alloys, minerals, and welding supplies and equipment, owns or operates mineral mining and ore processing facilities in Australia; Monterrey, Mexico; Carteret, N. J.; and Beaverdam, Va.

ALSO . . .

Stonega Coke & Coal Co. has scheduled a multi-million dollar mine and coal cleaning plant near Stonega, Va. The new operation, to be known

as the Wentz plant, will have a capacity of 450 tph. The Wentz mine will be fully mechanized and have belt haulage. In addition, a cleaning plant at Glenbrook colliery of Stonega, near Keokee, Va., has been scheduled and will have a capacity of 300 tph. It will be adjacent to the Glenbrook tipple.

Marble Cliff Quarries is exercising options on lands near Carntown, Ky., for future limestone operations.

Kentucky Power Co. recently broke ground at Louisa, Ky., for construction of a $39,000,000 electric power plant. The 265,000-kw station is expected to burn 750,000 to 800,000 tons of coal annually.

Marquette Cement Mfg. Co. has purchased a 15-acre tract near the Calumet River at Chicago, Ill., which it will use as the site of a multimillion dollar cement production plant. No date has been set for construction of the plant, but preliminary designs call for an annual capacity of 2,250,000 bbl.

The 23rd Annual ASME-AIME Joint Solid Fuels Conference will be held in Charleston, W. Va., at the Daniel Boone Hotel on October 24–25. The theme of this year's meeting will be "Economics in the Production and Utilization of Coal."

Six major producers of potash in the United States have joined together to establish a research foundation whose purpose will be to develop programs for "efficient and beneficial use of potash" in various countries around the world. Headquartered at 1102 16th Street, N. W., Washington, D. C., the membership includes Duval Sulphur and Potash Co., International Minerals and Chemical Corp., Potash Company of America, Southwest Potash Co., U. S. Borax and Chemical Co., and American Potash and Chemical Corp.

North American Coal Co. expects to bring into operation next June a $1,000,000 plant at Powhatan Point, Ohio, for the production of aluminum ore from waste material that exists in abundance at its coal mines. The company has a method, developed after four years of research with Strategic Materials Corp., that produces aluminum sulphate from this waste material.

This year marks 110 years of iron ore mining for Cleveland-Cliffs Iron Co. It was formed as Cleveland Iron Mining Co. to buy and explore iron ore lands. The company's present corporate name was formed early in its career from the consolidation of Cleveland Iron Mining Co. with Iron Cliffs Co.

The Dun's Review Presidents' Panel recently voted on the Nation's best managed companies. The top 20 included Aluminum Co. of America, Armco Steel Corp., and Inland Steel Co.

Coal mining operations at Springhill, Nova Scotia, at a virtual standstill since a mine disaster in 1958, are expected to resume shortly. The newly formed Springhill Coal Mines Ltd. is opening its colliery at the site of an old mine known as the Syndicate which was operated in the early 1900's. It is not in proximity to No. 4 or No. 2 mines where disasters occurred in 1956 and 1958. The mine will produce about 500 tpd of coal and employ about 150 men.

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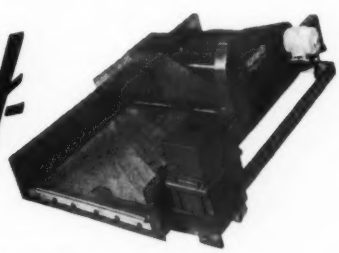

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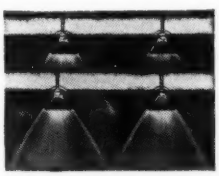

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★ *The ORIGINAL Deister Company • Inc. 1906*

Aluminium, Ltd., plans the construction of new facilities at Arvida, Quebec, for the production of aluminum by a basically new process. The new facilities, which are expected to be in operation in about two years, are designed as an experimental unit and will be operated primarily for the purpose of confirming the conclusions already reached concerning the production costs obtainable with the new process. The unit will have a capacity of 6000 to 8000 tons of aluminum a year. The new process does not appreciably reduce the large power requirement which is an outstanding characteristic of the conventional process, but it does give promise of substantial savings in other elements of production cost and in the investment required for a ton of capacity.

In an unusual venture, C. Reiss Coal Co. has halted railroad movement of coal from western Kentucky to Sheboygan, Wis., to use an all-water route. The operation is said to mark the first time in history that coal from mid-western coal fields has moved via an all-water route to Sheboygan. The coal will be shipped up the Ohio and Mississippi rivers to Chicago where it will be loaded into Great Lakes boat carriers for transshipment.

Strategic Materials Corp. and Universal-Cyclops Steel Corp. have signed an agreement for the joint development of a new process for using low-grade ores in the production of stainless steels and/or heat resisting alloys. Strategic Materials will build a $1,500,000 addition to its Niagara Falls, Ont., plant to utilize the Strategic-Udy process. Universal-Cyclops will furnish technical assistance for the new process.

Secretary of Labor James P. Mitchell recently announced that productivity in the bituminous coal mining industry rose 8.7 percent in 1959. Coal's increase was topped only by that of the basic steel industry, which showed a 12 percent rise in output per man-hour of production workers, and by anthracite mining, which had a 10.2-percent rise. This contrast with a 4 percent increase in productivity for all private industry for which data is available.

Stockholders of the Flintkote Co. have approved a proposed merger with the Diamond Portland Cement Co. of Middle Branch, Ohio, into Flintkote. The action also paved the way for Flintkote to acquire the M. J. Grove Lime Co. of Frederick County, Md.

According to Tass, the Soviet news agency, a closed TV circuit has been installed in a Siberian coal mine so supervisors can keep an eye on the miners.

BOOK REVIEW

HISTORY OF THE WEST VIRGINIA COAL INDUSTRY

Phil M. Conley; Education Foundation, Inc., Charleston, W. Va.; $3.95

The "History Of The West Virginia Coal Industry", as compiled by Phil M. Conley, surprisingly enough, is the first book ever published on that state's coal industry. Based on available records, the volume is rich in historical background, bringing to life a past that has been forgotten by the present generation. Anyone who is interested in the rise, and in some cases the fall, of various West Virginia coal fields and companies will deeply enjoy this volume. Sections are also devoted to "Laws and Methods of Mining" and "Transportation and Markets."

The introduction was prepared by G. R. Spindler, Dean, West Virginia University School of Mines, and the preface was written by the Honorable Cecil H. Underwood, Governor of West Virginia.

PROFESSIONAL LISTINGS

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THE REPORT CORNER

Recent Publications of Interest to Mining Men

U.S.B.M. Report of Investigations 5626, "Sulphur in Lignite: Form and Transformation on Thermal Treatment," by Walter W. Fowkes and Jerome J. Hoeppner.

U.S.B.M. Report of Investigations 5631, "Extracting Final Stumps in Pillars and Pillar Lifts with Continuous Miners," by R. W. Stahl.

U.S.B.M. Report of Investigations 5632, "Controlling Mine Fires with High-Expansion Foam," by John Nagy, Edwin M. Murphy and Donald W. Mitchell.

U.S.B.M. Report of Investigations 5639, "Methods for Analyzing Titanium Metal for Tin," by T. A. Sullivan, R. W. Lewis, L. Carpenter and B. J. Boyle.

U.S.B.M. Report of Investigations 5646, "Flotation of Pacific Northwest Chromite Ores," by S. V. Sullivan and W. A. Stickney.

U.S.B.M. Report of Investigations 5647, "Laboratory Beneficiation of East Texas Limonite-Siderite Iron Ores," by H. E. Powell and W. M. Dressel.

U.S.B.M. Report of Investigations 5648, "Injecting Solid Fuels into Smelting Zone of an Experimental Blast Furnace," by E. J. Ostrowski, M. B. Roger and L. J. Ropelewski.

U.S.B.M. Report of Investigations 5649, "Evaluating Anchorage Testing Methods for Expansion-Type Mine Roof Bolts," by A. J. Barry and J. A. McCormick.

Note: U.S.B.M. Reports of Investigations can be obtained from the Publications-Distribution Section, Bureau of Mines, 4800 Forbes Ave., Pittsburgh 13, Pa. They should be requested by number and title.

"Geochemistry of Carbonate Sediments and Sedimentary Rock—Part III, Minor Element Distribution," by Donald L. Graf, Circular 301, Division of the Illinois State Geological Survey, Urbana, Ill.

"Symposium on Mining Research—Ammonium Nitrate," Bulletin No. 98, University of Missouri, School of Mines and Metallurgy, Rolla, Mo.

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The split-type bolt is one of the first slotted bolts, and continues to be a favorite wherever split-type bolts are used. Many mines still prefer this type. The bolt is a full 1-inch in diameter, with cut threads and furnished with hex or square nuts and various size plates and wedges.

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Pattin expansion shells are available and serviced exclusively by Colorado Fuel and Iron Corporation, Denver, Colorado. Western mining companies should contact them direct for information and consultation.

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ALSO . . .

Clinchfield Coal Company's Compass No. 1 mine first-aid team from Barbour County, W. Va., won top honors in the annual Beckley, W. Va., First-Aid Contest on August 20. The meet is comprised of central and southern West Virginia teams and is the largest district meet in the Nation. The Compass crew, which beat out 32 other teams, already held the national and state championship. Second place went to the Harewood team of Semet Solvay Division of Allied Chemical & Dye Corp., third to the Itmann team of Pocahontas Fuel Co., fourth to the Gary No. 3 team of U. S. Steel Corp., and fifth to another Harewood team.

The U. S. Bureau of Mines research program for lead-zinc during fiscal year 1961 will emphasize mining research studies covering basic and applied aspects of rock drilling and ground support, and studies in extractive metallurgy. Other research will be directed towards improving recovery procedures at secondary smelters, investigating and reporting of mining and milling costs at selected plants, and making statistical studies regarding metal supply and demand to help guide the intensity and character of industry and Government research.

Armco Coal Mines of Armco Steel Corp. conducted their 29th first-aid contest and safety day at Montcoal, W. Va., on August 27.

Medusa Portland Cement Company's plant at Bay Bridge, Ohio, will stop production permanently September 30. The supply of marl, basic ingredient in cement manufacture, has diminished to the point where the local plant cannot continue to operate. After September 30 the plant will be used for storage, with finished cement shipped to Bay Bridge from other company plants.

Peabody Coal Company's Bee-Veer mine near Macon, Mo., achieved the best safety record of all Peabody mines for the 12-month period ended on June 30, 1960. During that time there was only one lost-time accident and the injured worker missed only six days of working time. The Russell Kelce Safety Trophy, Peabody Safety Flag, and custom-made souvenirs were presented to Bee-Veer local management and individual employes. The trophy, a large and beautiful gold cup, is presented by the company in honor of the memory of the late L. Russell Kelce, former president of Peabody.

National Lead Co. has announced the extension through June 30, 1965, of the contract with the U. S. Atomic Energy Commission for operation of the Feed Materials Production Center at Fernald, Ohio, which has been operated since 1951 by National Lead Co. of Ohio, a company subsidiary. The $110,000,000 facility converts concentrates of raw uranium ore, received from Africa, Australia, Canada and the Colorado Plateau area, to finished uranium metal shapes and forms for use at other AEC installations as feed for atomic piles, or reactors.

NEWS and views

Land Withdrawal to Aid Potash Development

The Department of the Interior has ordered withdrawal of 9445 acres of public lands from oil and gas leasing for ten years in San Juab and Grand counties, Utah, to facilitate development of potash deposits there. The deposits at Cane Creek—believed to be among the richest in the United States—will be mined at depths ranging from 2500 to 5000 ft. The withdrawal was ordered because it is not considered possible to fully develop the potash at these depths and at the same time continue drilling for oil and gas. Development of the Cane Creek deposits is contemplated by Texas Gulf Sulphur Co., who earlier this year signed an agreement with Delhi-Taylor Oil Co. covering acquisition and development of properties near Moab. In this connection, Texas Gulf recently announced that it has completed a core drilling program to evaluate reserves at Cane Creek. If final reports on the project are as favorable "as all interim reports have been," the company would plan to invest $20 to $30 million to construct facilities for producing commercial potash. Company studies to date favor a 10,000 tpd plant, a 2700-ft mine shaft, and provisions for a supplementary shaft when plant expansion permits larger tonnages to be processed.

Salt Lake Segregation Process to Employ Rotary Calciner

An indirect-fired rotary calciner will be used for the first time in this country in the salt coke segregation process for reducing lime-laden copper ore that so far has defied more conventional ore reducing methods. A producer in the Southwestern United States will employ the process where crushed ore, coke, and a halide will be heated and mixed in a 48-ft by 54-in. diam stainless steel calciner to produce metallic copper. The calciner operates in a gas-fired furnace at temperatures up to 1500°F. From the calciner, the mixture goes through a cooler, then into a ball mill classifier circuit and then to flotation cells for concentration. The installation is of interest because conventional acid-leach reducing methods are not generally economical for treating lime-laden copper ores that occur in the southwest U. S.

Cement Plant Bids Announced

Calaveras Cement Co., a division of the Flintkote Co., has announced that M & K Corp. was low bidder at $4,355,000 for installation of crushers, raw and clinker storage, mill buildings, kiln and auxiliary equipment at the company's operations near Redding, Calif. Homan & Lawrence Engineering Co. was low bidder at $1,585,000 for construction of raw and cement storage silos and packhouse. The new Calaveras plant, slated to be in operation in September 1961, will have a capacity of 1,500,000 bbl of cement annually.

Mill Contract Extended

Climax Uranium Co., operators of a 330 tpd uranium-vanadium ore processing mill at Grand Junction, Colo., recently executed an extended uranium concentrate purchase contract with the Atomic Energy Commission.

The new contract runs from August 1, 1960 to December 31, 1966, or to an earlier date when the company will have delivered to the AEC the maximum number of pounds of concentrate provided in the contract. Under the extension, the mill will continue to operate at about the same daily rated capacity as at present.

The contract extension to 1966—the first in the Uravan Mineral Belt of Colorado—in addition to providing for treatment of ores owned or controlled by Climax, contains provisions which reserve a position of mill capacity for production from qualified independent ore producers in the area. AEC's first contract with Climax was signed in 1950 and under it, the Grand Junction mill first delivered concentrate to the Commission in June 1951.

The extension is in accordance with an AEC announcement which provides for the purchase of appropriate quantities of U_3O_8 in the 1962–66 period from ore reserves developed prior to November 24, 1958.

ALSO . . .

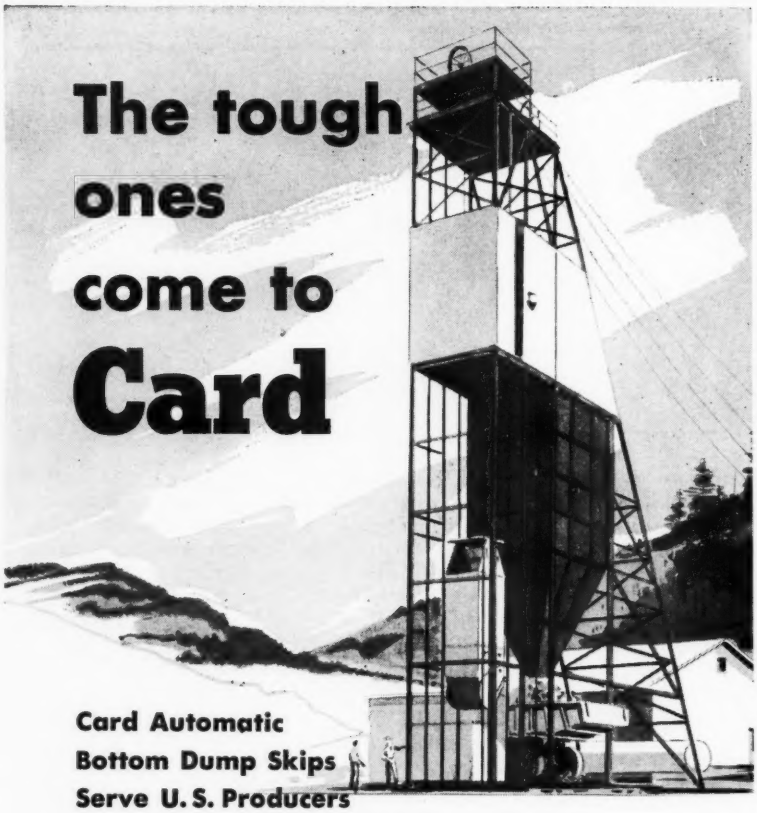
A two-year, $1,500,000 expansion is planned for the Lead, S. D., operations of Homestake Mining Co. The proposed expansion will provide for treatment of ore from deeper levels of the mine and increase mine output from 1,750,000 tons per year to 2,000,000 tons per year.

Three new contracts for mineral exploration have been approved by the Office of Minerals Exploration. The contracts are with Vitro Minerals Corp., to explore for beryllium in Juab County, Utah; Lithium Corp. of America, to explore for beryllium-columbium-tantalum at Custer, S. D.; and Cog Minerals Corp., to explore for mercury at Lake, Calif. Respective costs of the projects are $75,440; $26,640; and $35,060 with the Government share equal to one-half these amounts.

An American-Mexican combine has been awarded a concession by the Mexican government for development of a deposit reported to contain about 50 million tons of magnetite in the State of Colima and about 30 miles

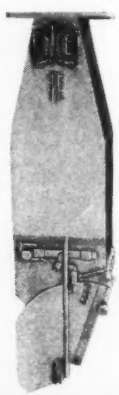
(Continued next page)

The tough ones come to Card



Card Automatic Bottom Dump Skips Serve U. S. Producers in most Major Mining Areas

This is a progress report on a relatively new idea. Beginning in 1956, increasing demand for the new Card automatic bottom dump skips has gradually brought them into service in a majority of the nation's principal mining areas—from Arizona to the Canadian line. In a typical operation two of these Card skips of approximately 150 cu. ft. capacity each are used to haul ore up a thousand-foot three-compartment shaft at a rate in excess of 900 tons per day.



In the initial year of operation, in one such installation, these automatic skips carried over 270,000 tons of rock before needing attention other than routine maintenance. The same successful design will prove out in your next project. It can be adapted to any capacity and specifications with ease.

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(Continued from previous page)

from Manzanillo, the main west coast port. The iron concession, which is the first of its type awarded in Mexico under the new mining code, requires that the ore be consumed in Mexico. The combine consists of Colima Mines, Inc., the American company, and Minera Ducro, S.A., the Mexican company.

Employes at the Chino Mines Division mill of Kennecott Copper Corp. have established a safety record of operating 600 days without a lost-time injury. During this period, an average 224 men were employed and the mill operated for more than 500,000 man-hours. The previous mill record was 524 days.

Susquehanna - Western, Inc., proposes to erect a plant south of Los Angeles for the production of expanded shale for use as a lightweight concrete aggregate. The company, which is a subsidiary of the Susquehanna Corp., has leased shale deposits near San Clemente and is conducting feasibility studies on the project.

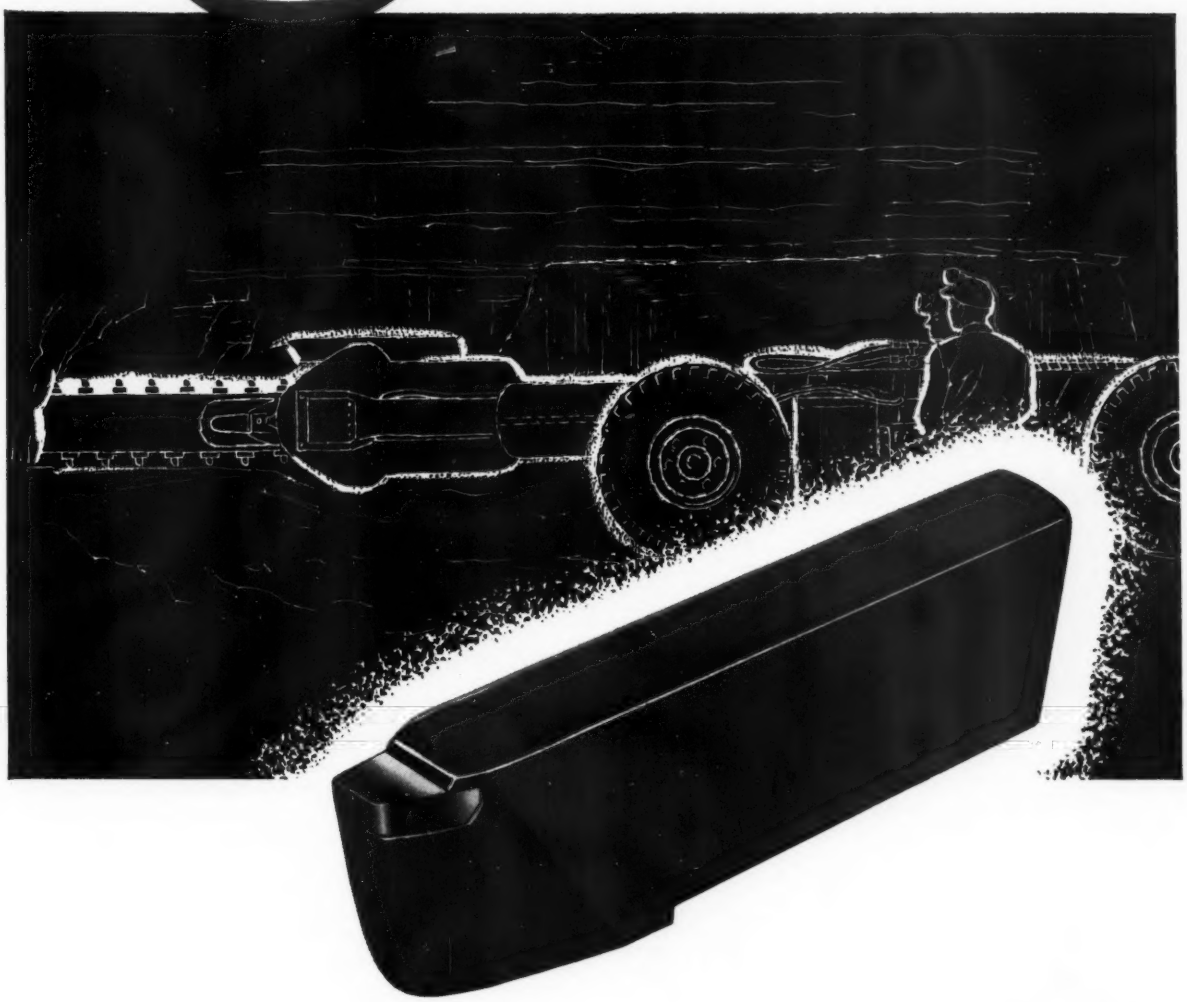
Through an exchange of stock on a share for share basis, International Uranium Corp. has merged with Western Smelting & Refining Corp. with the surviving company retaining the name of the latter. The merger was announced as providing a new corporate structure for an expansion in the fields of mining, smelting and refining of gold, silver, copper and various metals in the platinum group. The company's smelting and refining plant near Albuquerque, N. M., is slated to be in operation in early 1961 for treating ores from its mine and mill 25 miles away.

Utah's Delta uranium mine, which was abandoned in 1957 and relocated early in 1959, is again being operated. Originally an underground mine, it is presently being worked by open cut methods and plans call for production of about 1500 tons per month by the end of the year. The mine was once thought to have about 500,000 tons of ore containing 0.29 percent U_3O_8 in it. It was recently acquired by Central Oil & Mining Corp.

A five-ton diesel mine locomotive was recently donated by the Plymouth Locomotive Works and Hercules Motor Corp. to the Colorado School of Mines for use in its ex-

(Continued on page 96)

V-R RED BITS



NEW V-R Red Bit cuts down fines

V-R's new MS3 chain cutter bits are now ready for use on cutting machines and universal type miners. The proven chisel bit cuts faster and smoother without drag. Fines are minimized. V-R's lip design holds the carbide tip securely while maintaining fast cutting action. The MS3 Red Bit is another result of V-R's 30 years in carbide research and manufacturing experience. Quality carbide, engineering know-how and competent service assure more tonnage per machine and trouble-free production. Send for catalog VR-488 or call your V-R man today.

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(Continued from page 94)

perimental mine. The school's experimental mine, located at Idaho Springs, Colo., gives senior engineering students the opportunity to put their training to the test under actual field conditions.

Mill capacity of the Federal Uranium-Gas Hills Partners uranium processing mill at Riverton, Wyo., is being increased from 529 tpd to 800 tpd. The modifications, which are scheduled for completion in late October, will involve expenditures of about $180,000. Gas Hills Uranium is reported to have recently discovered what may be a major uranium ore body in the Shirley Basin. Drilling indicates the ore body is between 100 and 150 ft deep—shallow enough to be mined by open pit methods.

Rehabilitation work at the Ophir Hill (Utah) lead-zinc property of U. S. Smelting Refining & Mining Co. was recently started. Development work and some production is in progress by lessees of the property.

The new 1,400,000 bbl per year cement plant of Texas Industries, Inc., at Midlothian, Texas, has started production of portland cement. The company is said to be the first new company to enter the cement business in north central Texas in 25 years.

Uranium concentrate from the Shirley Basin of Wyoming will be purchased from Petrotomics, Inc., by the Atomic Energy Commission. Petrotomics, a partnership between Kerr-McGee Oil Industries, Inc., Tidewater Oil Co., Skelly Oil Co., and Getty Oil Co., recently obtained a contract from the AEC which provides for ore purchases through December 1966. The company, at its option, may build a mill for the 1962–1966 period or arrange for upgrading at existing mills; but prior to that period, AEC can direct the ore to existing mills.

An 800 ft, two-compartment, development shaft will be sunk at the Safford, Ariz., copper prospect of Kennecott Copper Corp. The shaft will not be in mineralized ground, and underground exploration of copper ores confirmed by surface drilling will be conducted from a crosscut driven for that purpose.

A 500,000 bbl per year cement plant will be built at Sutton, Alaska, by Permanente Cement Co., where it will exploit high grade limestone deposits on 240 acres upon which the company is said to have filed. The project reportedly will involve expenditures of about $5,000,000. Sutton is about 65 miles north of Anchorage on the Alaska Railroad.

An option on 9000 acres of land near Buffalo, Wyo., has been taken by Union Carbide Corp. to determine if coal deposits there are of commercial value.

Stockholders of Metaline Contact Mines Co. have been asked to consider acquisition of properties in the Metaline district of Washington in exchange for shares of its common stock. The property involved belongs to the Bunker Hill Co. and Day Mines Inc., and is contiguous to Metaline Contact property. Consolidating the properties would make an exploration and development program more feasible.

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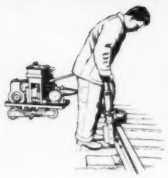

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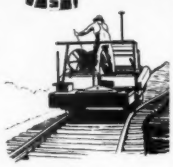

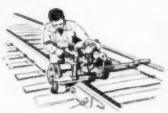

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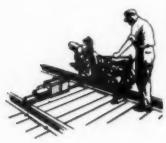

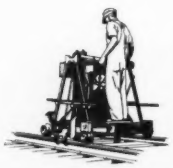

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manufacturers forum

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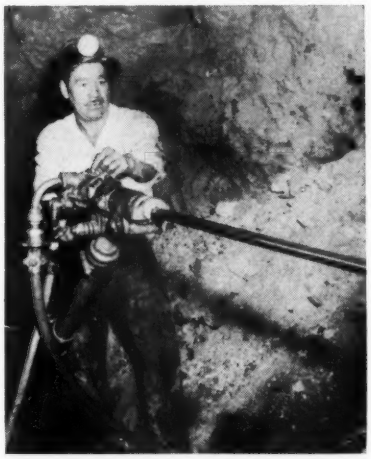


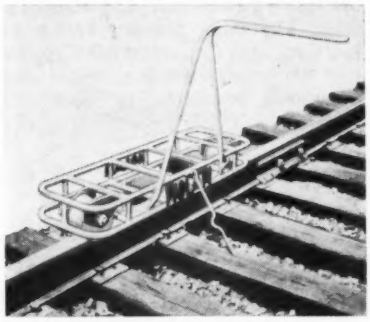
the drill's balanced design reportedly permits the operator to manipulate drill, rotate feed leg pressure control valve to raise the drill and operate a push-button thumb control to lower the drill without removing his hand from the handle grip. Drill is available with manual or power-retracted interchangeable feed legs. Drill can be locked in line with feed leg for use as stoper or for roof-bolting operations.

INTERNAL BUNKER VIBRATORS assure constant, free-flowing materials from wood, steel or concrete bunkers, according to Syntron Co., 703 Lexington Ave., Homer City, Pa. The unit consists of an electromechanical rotary vibrator mounted at the top of a long strip of steel. It is suspended down into the bunker, directly over the discharge opening. In operation the vibrator causes the steel strip to undulate violently—breaking down arching and plugging. The unit is furnished complete with the mounting structure supporting a five ft strip of steel, 18 to 24 in. wide on which is mounted the rotary vibrator. Additional lengths of strip steel can be welded to the unit to make up to a maximum length of 50 ft. For 220 or 440-volt, 3-phase, 60-cycle, a-c operation.

A NITRO-CARBO-NITRATE BLASTING AGENT, known as "Nilite" 101, has been announced by the Explosives Dept. of E. I. duPont De Nemours & Co., Inc., Wilmington 98, Del. It was designed, according to the manufacturer, to fill the need for a free-running, non cap-sensitive product of medium density for loading into holes of two in. diam and larger. In performance it is claimed to be equivalent to 60 percent extra dynamite on a weight basis with a density of 0.70-0.75 g./cc. Velocity is quoted at 9800 fps measured in five in. diam in air—higher velocity can be expected in larger diameter or under confinement. It is packaged in 50-lb multiwall paper bags, and is said to be considerably more sensitive to propagation than prill/oil mixtures.

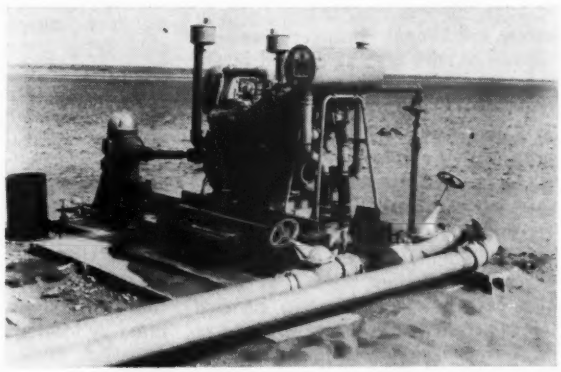
A RIPPER POINT said to "dramatically" increase ripping yardage has been introduced by Construction Equipment Div., ESCO, 2141 N. W. 25th Ave., Portland 10, Ore. The claimed advantages of the point are said to be due to a new ESCO alloy "12S" specifically developed for ripping, and the radical length, narrowness and sharpness of the design. ESCO markets the ripper point in four lengths to match ripping conditions. The 14 in. length is for ripping extremely tough material; the 16-in. point is intended for tough production ripping; the 18-in. point is designed for use under general ripping conditions, and the 20-in. point is for service in easily ripped materials.

A MANY-PURPOSE MINE TRACK DOLLY is available from the Nolan Co., Bowerston, Ohio. The vehicle is built of tubular high carbon steel;



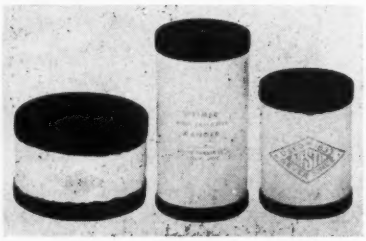
the wheels are of cast steel and are ball bearing equipped; and the deck is heavy mesh-expanded steel. Operator's handle is placed for assurance of correct balance and full control of heavy loads, and a spike securely holds dolly in loading position. Detachable handle permits carrying of unit when required. Lengths available are 50½ and 36 in.

A FIELD-TESTED COOLING SYSTEM for non-radiator cooled engines has been developed by the Construction Equipment Div., International Harvester Co., 180 N. Michigan Ave., Chicago 1, Ill. Called Flo-Matic, it is recommended for all heat-exchanger-cooled International engines. According to the company, the development maintains a high-volume, high-velocity coolant flow, producing more uniform engine temperatures. This reportedly extends the service life of valves, pistons, piston rings and sleeves. Hot spots and steam pockets are said to be eliminated and foaming and air entrainment problems, inherent with continuous duty applications, are controlled.



CONVEYOR BELTING known as BostRon is claimed by its manufacturers, Boston Woven Hose & Rubber Div., American Biltrite Rubber Co., P. O. Box 1071, Boston 3, Mass., to be a remedy for many operating causes of premature belt failure including moisture, impact, fatigue, abrasion, chemicals, and acids. These belts combine a reportedly hazard-proof carcass with Balanced Belt Construction and protect it with a Dulon cover. They are said to be highly flexible, permitting larger loads, narrower conveyor widths and lower handler costs. They also allow troughing to 45°.

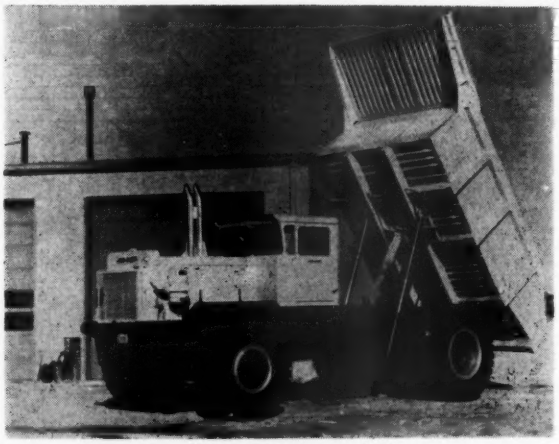
PRIMERS FOR INITIATION of low grade ammonium nitrates and other blasting agents have been announced by Austin Powder Co., Cleveland 13, Ohio. The three primers, known as Red Cap, Blue Cap and Black Cap, are said to be unaffected by water and completely insensitive to shock and abrasion with rifle impact sensitivity



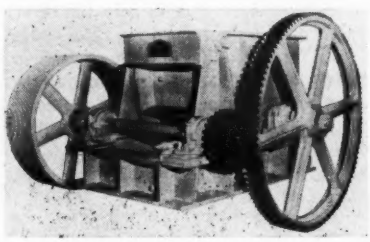
of zero. Made of special cast high explosive, primers have a speed of more than 22,000 fps. Red Cap and Black Cap are designed for initiating a minimum of 300 lb of low grade ammonium nitrate in large diameter holes. Blue Cap is for small diameter holes. All three primers are furnished with a central channel, permitting fast threading of detonating fuse through their entire length. In deep holes, additional primers can be slipped on the fuse at desired intervals.

A NEW TYPE COLOR-IMPROVED MERCURY LAMP which combines the advantages of a built-in metallic reflector, phosphor coating, and hard glass has been developed by Radiant Lamp Corp., Newark, N. J. Called Merco-White High Beam, the lamps also feature a combination of two light patterns, narrow and wide, so as to deliver maximum lumens and complete coverage to the work area. Four wattages are available. The 1000- and 700-watt lamps have R80 bulbs. The 400- and 250-watt lamps use R60 bulbs.

A WEIGHT-SAVING CORRUGATED BODY is being offered by KW-Dart Truck Co., Kansas City 41, Mo., on its model 35SL. Material used in the body of this off-highway hauler is strengthened by a corrugation process said to add rigidity and durability. This permits the truck's weight to be reduced by more than 4000 lb. The weight reduction permits faster deadheading and offers greater fuel economy. The model is equipped with a 450-hp diesel engine and features a three-speed transmission and three-stage torque converter with downhill braking feature.



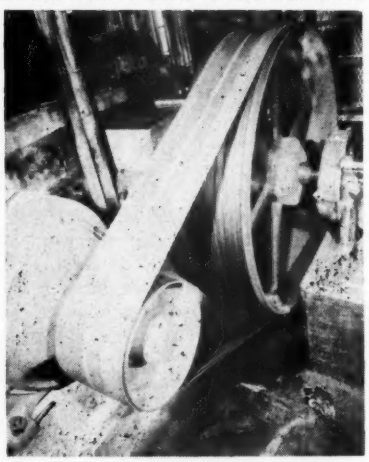
A SINGLE-ROLL CRUSHER, the Atlas has been developed for crushing such materials as soft gypsum, shale, coal, gypsum, coke, limestone and phosphate rock by the Pennsylvania Crusher Div., Bath Iron Works Corp., West Chester, Pa. Used as a primary or secondary crusher in continuous production lines, the Atlas reduces product size to maximum dimensions of 1½ to 8 in. It is available with roller diameters of 18, 24, or 30 in. to



handle feeds up to 26 in. thick. The roll is a one-piece, cast alloy steel shell keyed and shrunk onto a forged, heat-treated shaft. Teeth of various heights are arranged in patterns to meet the particular crushing requirements. Frame is fabricated of rolled steel and lined with renewable carbon manganese steel plates in all areas subject to wear.

AN ADJUSTABLE BRACKET which is said to control spillage and increase conveyor system capacity is being offered by Florida Conveyor and Equipment Co., Mulberry, Fla. Advantages claimed for the catenary type idler bracket are : (1) elimination of "jiggling" and premature cable failures, by assuring uniform contact of idler and belt; (2) elimination of skirting grooves in belt, by making possible a parallel and same angle "perfect mating" of belt and skirt boards; (3) elimination of spillage and wandering belts due to off-center loads, through its adjustability to deep troughs at loading points.

GRINDING ROCK INTO POWDER for insulation has created extreme atmospheric conditions at the Plymouth Meeting, Pa., plant of Philip Carey Co. A big problem was the short life of the V-belts on compressors, which are driven by a V-to-flat drive, and, more important the time it took to change belts. In looking for a solution, the company decided to switch from V-belts to flat-belt drive



and use a 12-in. Texalon belt—a nylon core synthetic belting manufactured by J. E. Rhoads & Sons, Wilmington 99, Del. The synthetic belting has reportedly cut replacement costs and reduced shutdown time.

—ANNOUNCEMENTS—

Charles E. Haney, works manager, Foundry Production Department, recently was named a vice president of **Electric Steel Foundry Co.,** Portland, Ore.

C. H. Haney

Haney, who will continue as works manager, started his ESCO career as engineer in charge of the Taiwan Cement project, and by 1954 had advanced to works manager at Portland.

Other company changes include naming **Bob Zwald,** to succeed **Dar G. Johnson, Jr.,** as assistant to the general sales manager. Johnson becomes manager of sales, mill products, ESCO-Southwestern with headquarters in Los Angeles. **Jack McNally,** manager, product promotion, has been named to Zwald's former position as advertising manager with McNally being succeeded by **Paul Fillinger,** formerly of Portland sales.

Bucyrus-Erie Co. has announced the election of **Eugene P. Berg** as executive vice president. Berg was formerly general manager of Chicago operations for Link-Belt Co., where he was responsible for sales, manufacturing, finance, engineering, industrial relations and all phases of management.

Cummins Engine Co., Inc., Columbus, Ind., announces the appointment of **C. R. Boll,** formerly vice president-sales, to become executive vice president-marketing and of **R. W. Franck,** formerly director-sales, to become vice president-sales. Boll has advanced to his present position on the basis of 14 years experience with the company in sales and sales management, and Franck has been in the same area of duty for the company since 1948.

Joy Mfg. Co. has announced the appointment of **Stephen Laskevich, Jr.,** as District Manager for the Knoxville, Tenn. district sales office covering the states of Kentucky, Tennessee, Virginia, North and South Carolina, Georgia, Florida, and Mississippi. He will be responsible for sales and service of Joy's line of rock drilling and related pneumatic equipment for open pit mining and underground metal and hard rock mining.

Jeffrey Mfg. Co., Columbus, Ohio, has announced the appointment of **Paul R. Williams** to be assistant service manager, mining division and of **Robert D. Greer** to be sales engineer, apparatus sales, mining division. Williams has been connected with the coal industry since 1949 through association with Pocahontas Fuel Co., T. C. & I., and U. S. Steel Corp., while Greer has had industry experience with Inland Steel Co. and an equipment manufacturer.

Burt M. Powell, advertising manager of **Caterpillar Tractor Co.,** Peoria, Ill., since 1953, and a member of the Caterpillar staff since 1935 recently retired and is being succeeded by **Charles B. Leber,** who has been with the company

B. M. Powell

C. B. Leber

since 1947 when he joined as a trainee. Leber has held various supervisory positions in sales including district representative, assistant sales manager, sales training manager and manager, sales division of defense products.

James E. Quinn, manager of **Denver Equipment Co.'s** uranium processing equipment sales, has been named by the company to be general sales manager.

United States Rubber Co. announces the appointment of **William R. Tise,** formerly West Coast sales engineer for conveyor products sales, to be chief engineer for the department with new headquarters in the company's Passaic, N. J., plant.

H. K. Porter Co., Inc., Connors Steel Div., Birmingham, Ala., has announced the appointment of **West W. Callender** to the post of Mine Roof Bolt product manager in addition to his duties as product manager, Rail and Trackwork.

CATALOGS & BULLETINS

INTEGRATED DRIVE SYSTEM. *The Louis Allis Co., 427 E. Stewart St., Milwaukee 1, Wis.* Syncro-Range-Drives, ranging in sizes from 2 to 15 hp, and providing adjustable speed of synchronous induction motors running in exact synchronism over a wide range of speed, are the subject of Bulletin 111. The drive is an integrated system consisting of an adjustable frequency power supply, one or more Syncro-Spede drive motors, and a control panel.

SCREW CONVEYOR DRIVE. *Link-Belt Co., Dept. PR, Prudential Plaza, Chicago 1, Ill.* Folder 2718, "Type B Screw Conveyor Drive," lists sizes available in relation to screw diameters and gives selection data for the company's standard double reduction shaft-mounted speed reducer drive for direct application to screw conveyors.

GAS TURBINE. *General Electric Co., Schenectady 5, N. Y.* Bulletin SAE-109A describes General Electric's Model 720/722 industrial and marine gas turbine, and includes performance specifications, dimensions and installation data, fuel specifications, a development history, a summary of reliability testing, exploded and cutaway views of the engine plus a listing of current field installations and a review of application potential.

MECHANICAL SIZE REDUCTION. *Pennsylvania Crusher Div., Bath Iron Works Corp., West Chester, Pa.* A 40-page book, "Handbook of Crushing" covers subject of mechanical size reduction. Various reduction methods—impact, attrition, shear and pressure—are discussed, as are the many kinds of crushing equipment. Closed circuit crushing systems are also described, and the various factors to be considered in selecting crushing methods for particular applications and materials.

V-BELT AND INDUSTRIAL HOSE. *Dayton Industrial Products Co., 2001 Janice Ave., Melrose Park, Ill.* Catalog No. 260, punched for notebook insertion, covers the company's line of industrial V-Belts, including Cog-Belt and Poly-V and fractional horsepower types, as well as sheaves and industrial hose, and lists data on sizes, dimensions and prices. A special section on hose lists information about molded braided, horizontal braided, machine-built wrapped fabric, hand-built wrapped fabric and woven jacket hose.

ROTARY TABLE FEEDER. *Chain Belt Co., Milwaukee 1, Wis.,* Bulletin No. 6093 describes three standard Rex Rotary Table Feeders, providing outline drawings, dimensions and specifications. The feeders, designed for controlled feeding of sand, crushed ore and other similar bulk materials, are said to provide an efficient method of metering material from vertical storage bins. They also reportedly allow constant, accurate control of the quantity of material fed onto conveyors and processing equipment.

(Continued on next page)

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CONTROL TAPE. *National Vulcanized Fibre Co., 1060 Beech St., Wilmington 99, Del.* Bulletin 1313 is a data sheet describing Peerless fibre control tape for machine tool control and data processing applications. This tape is made from vulcanized fibre and reportedly features toughness, durability, high opacity, and a low stretch factor.

MOTOR GRADER. *Advertising Div., Caterpillar Tractor Co., Peoria, Ill.* Features contributing to high productive capacity and long life in the new Caterpillar No. 12E Motor Grader are emphasized in Booklet No. 33799, titled "Here's Why the Caterpillar No. 12 Series E Motor Grader Gives You Top Value."

CONVEYING SYSTEMS. *The DAY Co., 810 Third Ave., N. E., Minneapolis, Minn.* Bulletin illustrates and explains efficiency gains possible with DAY low density or high density systems. Typical arrangements are shown as well as several installation photographs.

MACHINE FOR STORAGE AND RECLAMATION WORK. *Sauerman Bros., Inc., Dept. M-30, 620 S. 28th Ave., Bellwood, Ill.* Storage and reclamation of bulk materials by DragScrapper machines are described and illustrated. Parts 1 and 2 of Catalog E cover outdoor and indoor material handling; Part 3 describes the buckets, blocks, hoists and other components of these machines.

INSULATION FOR WIRE AND CABLE. *Dow Corning Corp., Midland, Mich.* Manual claims increased reliability, greater versatility and longer life as the outstanding characteristics of wire and cable insulated with Silastic brand silicone rubber. The brochure uses data charts and graphs to explain its story in support of these claims. Also included are a variety of existing applications for Silastic protected wire and cable, depicted in pictures.

LIQUID CYCLONE. *Dorr-Oliver Inc., Stamford, Conn.* The company has revised and reissued its bulletin No. 2503, describing rubber-lined DorrClone liquid cyclone classifiers. Type FR DorrClone, described in this brochure, is available in 6, 12, and 24-in. diams.

HYDRAULIC HOSE, COUPLINGS AND FITTINGS. *Anchor Coupling Co. Inc., 342 North Fourth St., Libertyville, Ill.* Company has made available copies of a 21 by 32 in. Wall Chart for use as a "ready-reference" for all of its line of reusable hydraulic hose, couplings and fittings. Shown are dimensions and illustrations of these products made up to enable fluid power users to easily find the Anchor catalog numbers of the products. To supplement the Wall Chart, Anchor has also released a ten-page leaflet and Catalog No. D-1, to round the information needed in selecting and using these products.

SPRINGS. *Alco Products, Dept. 906-R, Box 1065, Schenectady, N. Y.* "ALCO Springs for Industry" contains formulas, data, illustrations and drawings describing all types of hot- and cold-wound springs made by this company, and includes a section outlining such considerations of spring design as working stress, modulus and design stress, with an accompanying table setting forth the physical properties of spring materials.

FEEDERS AND ROTARY VALVES. *Fuller Co., Catasaqua, Pa.* Bulletin F-5A describes and illustrates the complete line of the company's roll and vane-type feeders and rotary valves. The feeders, built of cast iron or iron and steel combinations, are designed to handle a large variety of dry pulverized and granular materials.

WORK GLOVES. *Glove Div., Riegel Textile Corp., Conover, N. C.* A selector manual covers basic types and styles of work gloves. Manual includes tips on grades of leather, chemical resistance and physical properties of various plastic coatings, in addition to information on basic cuts, cuff styles and other specification detail.

DRUM HOISTS. *Vulcan Iron Works Co., 2960 S. Fox St., Englewood (Denver), Colo.* A wide variety of Vulcan-Denver mine and utility hoists are highlighted in Bulletin No. AC-6002. Included are single drum and double drum electric hoists from 1000 lb to 50,000 lb rope pull, diesel and gasoline engine powered single drum hoists, low speed heavy duty winch hoists and the automation of small hoists at reasonable cost.

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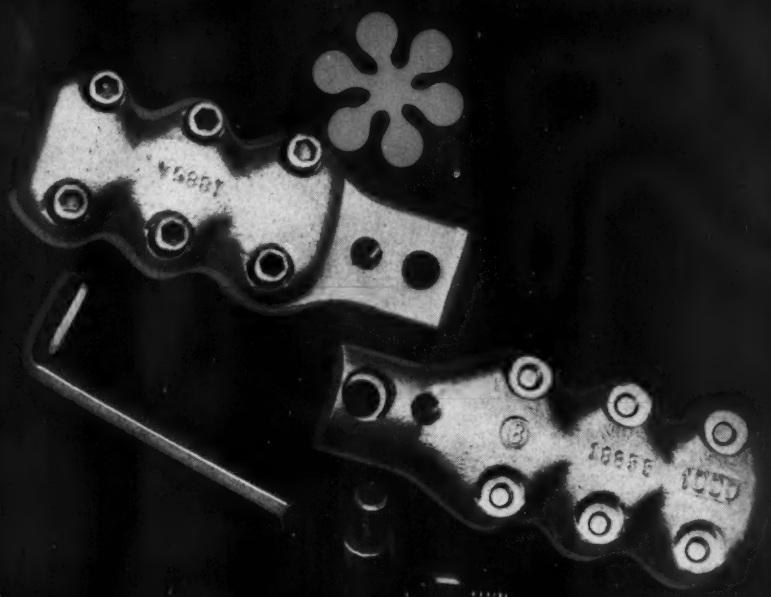
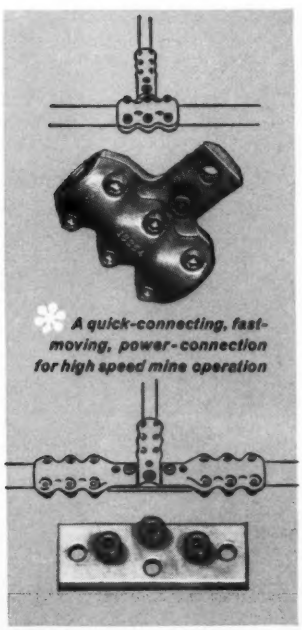
O-B Designs for Mining Men:



RESULT: you can make connections

between seven popular sizes of copper or aluminum cables . . . joining the same or different sizes . . . either copper or aluminum



A quick-connecting, fast-moving, power-connection for high speed mine operation

10050-M

FAST . . . The new O-B Cable Connector makes or breaks a cable connection simply with the turning of two cap screws. These sturdy fittings are especially designed for sections that are picked up and moved frequently.

VERSATILE . . . You can add or remove sections of cable to keep pace with fast machinery. You can make tap-offs, 3-way connections between cables, or a variety of switch and panel arrangements . . . all in minutes!

SIMPLE . . . Your O-B Cable Connectors give you the advantages of "built-in" cable connections that hook-up or disconnect simply. No specialist needed . . . saves time and labor on the job.

Write us . . . or see your local O-B sales-engineer to order the new O-B Cable Connectors. You'll find—as others have—that they make moving easier, faster, and considerably cheaper. OHIO BRASS COMPANY—MANSFIELD, OHIO, Canadian Ohio Brass Company, Ltd., Niagara Falls, Ontario.

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EXPANSION SHELLS AND PLUGS · LINE MATERIALS · SAFETY AND CONTROL EQUIPMENT · ELECTRIC HAULAGE MATERIALS

New M-S-A® AIRSLIDE* Rock Dust Distributor increases hopper capacity 25 times

Up to now, hopper capacity for face rock dusting machines has been limited. It has been held to 160 pounds of rock dust by seam height and the need for steeply angled hoppers to keep rock dust flowing.

Now, with the Model SC AIRSLIDE you get hopper capacities from *1000 to 4000 pounds of rock dust* . . . an increase of 25 times.

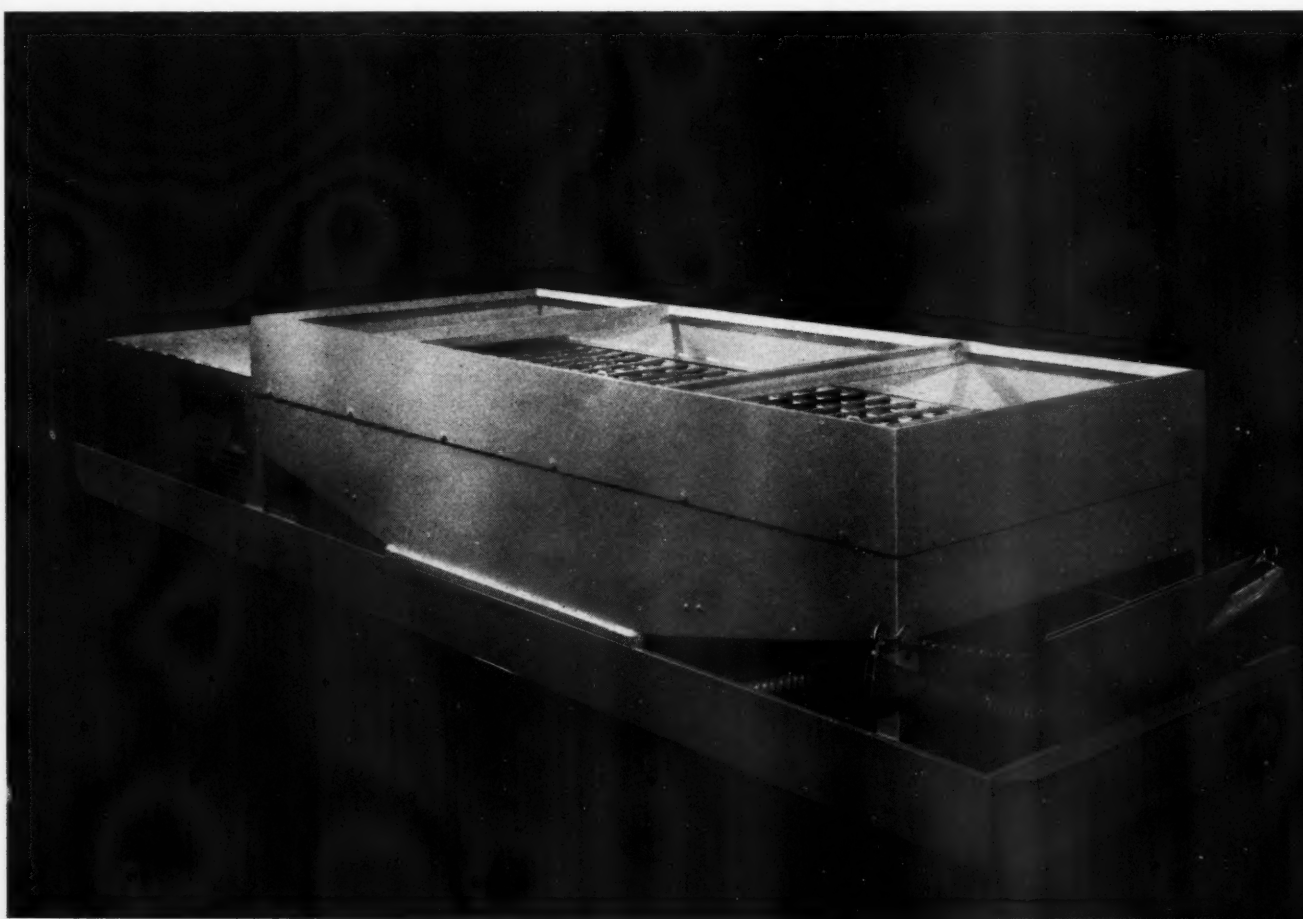
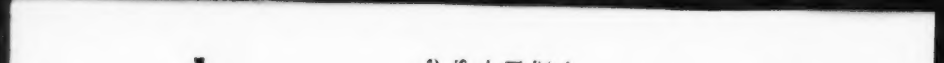
AIRSLIDE METHOD MAKES IT POSSIBLE

The AIRSLIDE method fluidizes rock dust so that it flows almost like water. A heavy belting, with uniform porosity, located in the bottom of the hopper, introduces low pressure air into the rock dust. This fluidizes the dust and makes the flow uniform and constant, even if the dust is damp. The steeply angled hopper is unnecessary. In fact, the rock dust will even flow down a 6° slope.

DISCHARGE RATE UPPED 6 TIMES

In addition to greater capacity, the discharge rate of the AIRSLIDE has been increased six times, to 600 pounds per minute. Large capacity and high discharge rate permit the volume dusting needed to keep pace with rapid advance work. AIRSLIDE uniformly covers ribs, roof and bottom in one operation, using one man. Cuts your dusting costs . . . noticeably.

For additional information call your MSA Representative. Or write, Mine Safety Appliances Company, Pittsburgh 8, Pa. In Canada: Mine Safety Appliances Company of Canada, Ltd., Toronto 4, Ontario.

*T.M. of Fuller Company

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